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Location of Industries

THE attention which, in the recent reports of the Commissioners for the Special Areas, has been directed to the attraction to, and the stimulation of, industry within those areas is only a particular example of the increasing interest which is being taken in the location of industry in Great Britain. The importance of rehabilitating the depressed areas of the country, whether those specially scheduled in the Special Areas Act or those other 'black spots' of the country such as the weaving and coal-mining areas of Lancashire, where unemployment is at least as great as in some of the Special Areas, and the signs of revival even less, is only one of many considerations bringing this matter to the front.

In his third report, the Commissioner of the Special Areas in England and Wales, while repudiating the idea of direct State control of the location of industry, advocated some measure of indirect control in the proscription of the location of industry in the London area, except for very definite and special reasons. Although this suggestion was intended to benefit the Special Areas, the argument rested at least as much on the relative vulnerability of London and the home counties, and the latter factor is obviously one of which increasing account must be taken unless we succeed in evolving a much more promising international order.

At the same time, the location of industry, like the planning of cities and towns, assumes greater importance from the increasing danger of destroying by indiscriminate building the amenities and beauty of our countryside. Ribbon-building has already done irreparable damage on both highways and coast, and unless effective control is exercised in these matters, as in questions of atmospheric or riparian pollution, little may be left to us of the rich heritage of rural England which was ours at the commencement of this century. Finally, transport considerations themselves are enforcing the consideration of the location of industry, so as to avoid the economic and social wastefulness and strain upon health involved in carrying immense numbers of tired people long distances to and from their work in overcrowded vehicles occupied only for a small fraction of the day.

Town planning, the location of industry, national health and defence, and the preservation of rural England, are in fact essentially different facets of one problem calling for long-range statesmanship and resolute scientific investigation. The strong criticism which the Government proposal to build an aircraft factory at White Waltham, near Maidenhead, received in the House of Commons, and the indignation which it aroused elsewhere, was due as much to the Government's countenancing Departmental violation of this principle as to the threat to the amenities of the Thames valley and the disregard of the claims of the Special Areas and the Commissioner's recommendations. Happily, the volume of protest, from all parties, was such that on January 26 Mr. Baldwin announced that the scheme had been abandoned, and that a new site will be sought in Lancashire.

It is not the least of the services performed by Mr. Malcolm Stewart, until recently Commissioner for the Special Areas, that he has so repeatedly emphasized the necessity for considering these areas as a problem of economic and social redevelopment on a very wide basis, calling for a definite national policy. The point is further stressed in an admirable broadsheet entitled "The

Location of Industry" which has just been issued by Political and Economic Planning (P E P). It is not merely that we are tending to consider the wider economic and social costs of different industrial policies and to realize the heavy offset to prosperity in the Midlands and South represented by wretched and paralysed groups of communities in Wales and the North. Increasingly we are coming to appreciate that there are definite opportunities of reconstruction and replanning in the present situation, which, if wisely used, may involve almost as great benefit to the whole community as to any special section for whose benefit they are immediately initiated.

The Government itself has repeatedly emphasized the experimental character of the Special Areas Act. From the experience of the selected areas was to be crystallized all those methods which could be adopted in other areas suffering from heavy unemployment. The Special Areas were essentially a large-scale social experiment. On this point the valuable study "Re-adjustment in Lancashire"*, prepared by members of the Economics Research Section of the University of Manchester, bases one of its most powerful arguments for inclusion of the weaving districts of Lancashire within the Act. The present limits of the Act are arbitrary and convenient, rather than based rationally on economic or geographical facts, but can be justified for the purpose of an experiment so long as the experiment is representative. "Re-adjustment in Lancashire", however, seizes upon the point that the four areas so far selected are not representative of conditions in the weaving districts, because, unlike all the Special Areas, the rate of unemployment there is higher for women than for men.

The main importance of this most recent survey by the University of Manchester lies in the analysis and exposure of conditions in the weaving district. The case for including this area to obtain data for conditions not yet covered by districts already scheduled is presented with all the thoroughness, lucidity and impartiality which we have learnt to associate with the work of this Economics Research Section. There are, however, other matters bearing on the location of industry in Lancashire to which the investigation also directs attention. One of its principal suggestions is in regard to the establishment of a trading estate and the provision of capital at low rates to provide a favourable environment for local industrial enterprise, particularly with the view of attracting industries employing women. Special attention is directed to the possibility of the district becoming a large and growing centre for the clothing trades.

* Re-adjustment in Lancashire. By Members of the Economics Research Section, University of Manchester. Pp. vii+137. (Manchester: Manchester University Press, 1936.) 4*s*. 6*d*. net.

Former strictures upon blind-alley work, casual employment and the exploitation of young persons as well as of the unemployed in Lancashire generally are repeated, and the social evils which flow from an industry continually discarding its workers as they become older are still far from receiving the attention they demand. The possibilities and limitations of road construction in the area in regard to unemployment, of cleaning up the face of the country by demolishing derelict mills and similar measures are also considered, and the investigation makes it clear how little the rearmament programme can contribute to the solution of Lancashire's most intractable problems. This sober but impressive marshalling of the facts should at least assist to secure fair consideration for an area much greater in size than one or two of the Special Areas, and no less deserving.

If the investigation we have just discussed reveals the limitations of the present Special Areas Act, and the necessity for fresh schedules or for the rapid extension of the experience gained to other 'black spots' of unemployment, the need is emphasized for a national policy and above all for the consideration of the location of industry by creative minds free from prejudice and competent to take into account all the many aspects of national and social policy and well-being involved. The case for a national policy is the more imperative since its realization in practice depends upon the utilization of the opportunities of reconstruction and development afforded not merely in the Special Areas but also in special emergencies.

The most cursory glance at this problem should indicate how interlocked is this whole question of the location of industry and national reconstruction, and the importance of a central authority powerful and unbiased enough to secure action on behalf of the national and not sectional interests. The comparison cited in the P E P Broadsheet between the treatment of the Special Areas and the subsidizing of the sugar beet industry alone illustrates how disproportionate is our present policy, and the need for some wider co-ordination and vision. The wisdom of subsidizing the sugar beet industry has been attacked on scientific grounds, but however great the intrinsic merits of the sugar beet subsidy, it is difficult to defend the subsidizing in this way of a population of about half a million, in comparison with the treatment of a population more than eight times as great in the Special Areas and in considerably more desperate straits. Drift from the depressed areas will only be checked as it is made worth while for a sufficient proportion of the natural leaders who are thrown up in each area to stay in it happily, doing constructive work instead of becoming narrowed and embittered, and quitting it in favour of somewhere more attractive.

The Special Areas are merely a particularly acute and painful example of the growing disequilibrium and sapping of vitality created by the excessive expansion of the metropolis. Moreover, years of mismanagement and neglect rather than sudden and unforeseeable misfortune are responsible for tragedies such as those of the coal-mining, cotton, fishing and sections of the agricultural industries, together with the areas mainly dependent upon them. The conclusion is inescapable that in future all major adjustments of policy should be examined not only with reference to their effects on the industry or other activity concerned but also with reference to their effects on the balance of national development. A constructively-minded Government, ready at the first signs of trouble to invest money in development work such as trading estates and new or improved communications, to bring in fresh industries or marketing measures and research to stimulate backward industries, could probably have salvaged many million pounds of expenditure in the last dozen years which has led the industry or area concerned no nearer a permanent self-supporting basis. "Re-adjustment in Lancashire" and the P E P Broadsheet are yet further reminders of the part which scientific investigation must play in the development of economic, social and industrial policy, and of the dire peril which attends neglect or failure to secure a more balanced national development and reconstruction in which internal strains between different areas and industries are minimized and a reasonable measure of social justice maintained.

The Science of English History

Roman Britain and the English Settlements
By Prof. R. G. Collingwood and J. N. L. Myres. (The Oxford History of England.) Pp. xxvi+515. (Oxford: Clarendon Press; London: Oxford University Press, 1936.) 12*s*. 6*d*. net.

THIS volume on Roman Britain and the English settlements is the first (though not the first to be published) in a series of fourteen covering the history of England, edited by Prof. G. N. Clark. The full-dress treatment of the theme commences with Cæsar's invasion, but this is preceded by a thirty-page introduction in which the geographical background and the prehistory of Britain are sketched in. Prof. Collingwood's contribution carries us through the Roman period into the fifth century; there Mr. J. N. L. Myres picks up the story, discussing that same century from the Anglo-Saxon point of view, and then the general problems of the English Settlement.

In 1910 Sir Charles Oman produced his very successful "History of England before the Norman Conquest". Though the new History is on a slightly larger scale, the two works are closely comparable, and it is interesting to see how they differ. Confining ourselves for the moment to the Roman period, Oman's survey is mainly military and political, based on documentary evidence (including coins and inscriptions). Collingwood, on the other hand, devotes more than one third of his pages to economic history and cognate studies. It is archæology that has made this possible in a period in many ways so ill-documented. The remarkable progress made by the science of the spade in recent years, and especially since the Great War, is familiar to all; a single contrast will bring it home. Some seventeen years work at Silchester, completed in 1906, laid bare the plan of a Romano-British town, but nothing else; on the other hand, three years work at Verulamium in 1932–34 revealed the history of an experiment in urbanization extending over nearly half a millennium, its growth, changes, vicissitudes and decay. On the military side, again, the post-War labours of field archæologists on the Roman Wall, at Richborough, Caerleon, Segontium and many other sites have given a new vitality and precision to the history of the army. The vigour of the development of archæology is also shown by the extent to which the natural sciences are drawn into the orbit of its research, and by the success with which novel techniques such as air photography are being exploited. All such aspects of field work are reflected in this volume, and help to mould its character.

Prof. Collingwood for many years has been one of the leaders of Roman studies in Great Britain, and speaks in this book with authority; he writes with that feeling for style which fortunately has never deserted the English historian. Special attention is due to his study of the interplay of life in town, in villa and in hamlet, and his exposition of the two agricultural methods employed in Roman Britain. The shift of the economic centre of gravity from town to countryside in the third century A.D. is seen to be a fact of prime importance.

Mr. Myres reverts to J. R. Green's method of approach, laying emphasis on the topography of Britain in relation to the English settlement. Recent studies in place-names and the history of institutions, and the attention now being devoted to Anglo-Saxon antiquities in their stylistic and distributional aspects, provide him with a range of data far wider than Green controlled. But the unresolved differences of opinion among contemporary scholars on many important aspects of his theme, the publication of Mr. R. H. Hodgkin's "History of the Anglo-Saxons" while his own was in progress, and the insufficiency of the available evidence, direct or indirect, combine to render his contribution less assured than that of his colleague. Nevertheless, it is an independent and acute study, embodying original research into the problems of a peculiarly difficult period; the section on the "Character of the Conquest" may be selected for special commendation.

To treat archæological material in the traditional historical manner, that is, with maps but without illustrations, offers a difficulty not hitherto surmounted. It was attempted for the "Cambridge Ancient History", but failed; for supplementary volumes of plates were issued at a later date. In this History, Prof. Collingwood's challenging thesis on Celtic and Roman art loses much from the lack of pictures; Mr. Myres, despairing of indicating verbally the quality of Anglo-Saxon art, "reluctantly omits" a review of the subject.

We have mentioned maps as essential to a history; and it is regrettable that the chief map in this book—that of Roman Britain—should be inadequate. The methods of symbolism adopted fail to bring out clearly the limits of the highland and the lowland zones of Britain, the importance of which is emphasized throughout the book; while the areas of naturally open country in the former zone (which it must be presumed the white areas on the map are meant to indicate) can scarcely be accepted as probable by anyone familiar with the geology and topography of, for example, Wales and the south-western peninsula. Cyril Fox.

Reactions in Uganda

Africa Answers Back

By H.H. Prince Akiki K. Nyabongo. Pp. x+278. (London: George Routledge and Sons, Ltd., 1936.) 7*s*. 6*d*. net.

As the work of a prince of the blood-royal of Uganda, who has been educated at Yale and Oxford, "Africa Answers Back", although in form a fictional biography, is a work which deserves more than casual consideration. It is significant as the mental reaction of an educated African to his contacts with European civilization.

In outline, the story runs: A son is born to an important chief, who has three hundred and seventy-five wives. The boy is educated in a missionary, and later in a private venture, school. His father dies in an epidemic of smallpox, which is stamped out by wholesale vaccination performed by a German doctor from Kiziba, Tanganyika, and doctors summoned hurriedly by drum from Mombasa and Zanzibar. The son is elected chief and introduces reforms, but is compelled to revert in part to traditional ways.

This thread of the story will indicate its limitations. The point of view is aristocratic. No attention is given to the social and economic problems of the people, which indeed in some ways are less insistent in Uganda than elsewhere in African administration. However, as a picture of the functioning of a great polygamous household and of the duties and ceremonial of its individual members, the book is more illuminating, even if less comprehensive, than most formal treatises.

Three contrasted points of view are presented with no little skill. First there is that of tradition, represented by the old chief, who, though open-minded up to a point towards the innovations Christianity would wish to introduce, is baffled by its inconsistencies, and convinced by his own line of argument that customary ways such as, for example, polygamy and birth control, are best for his generation, whatever a later generation may decide to do. Secondly, there is the missionary point of view, presented in a form rather out of date now, and, of course, as seen through native eyes. Thirdly, there is the point of view of the educated native, seen as it develops from the tribal attitude of the immature boy into the sophisticated and superficially acute outlook of the young man, who accepts the science of Western civilization as in most, but not all, respects superior to his own system, but is incapable of taking up the attitude of faith of that civilization.

The closing note is pessimistic. The missionary retires defeated. The hero, as a reformer, is regarded askance by his people, and as a monogamist, his single wife proving a shrew, is forced at her insistence to marry three or four more wives for the sake of peace in which to work out his plans.

Music in Films

Film Music: a Summary of the Characteristic Features of its History, Aesthetics, Technique; and possible Developments. By Kurt London. Translated by Eric S. Bensinger. Pp. 280 + 28 plates. (London: Faber and Faber, Ltd., 1936.) 12*s*. 6*d*. net.

IT is characteristic of our times that, while the abstract and practical aspects of transient political trends are over-documented in book form, the corresponding aspects of such permanently revolutionary factors in everyday life as broadcasting and the sound film are, on the whole, treated only in an ephemeral literature of specialized circles.

The attempt to make a balanced estimate of the inseparable technical and æsthetic problems of the sound film has not yet been made with any considerable measure of success. In the volume under notice, Dr. Kurt London succeeds in making us realize the profundity of the problems, but does not attain balance. He is described as a thinker, a musician and a technician; but his thinking stops short of the need for compelling the technician to be the slave of the musician. His error of outlook is shared by many distinguished musicians; it is implicit in Mr. Constant Lambert's introduction to this book, in which he says—apparently with some surprise and disappointment—that "Wireless has not so far compensated the composer by providing him with a new art form".

The book is in six parts, dealing in turn with "Origins of Film Music", "Music with the Silent Film", "Mechanical Interlude", "The Sound Film", "Training the Rising Generation" ("On the Establishment of a Microphone Academy") and "The Future of the Sound Film". On the technical side, the good description of the musical instruments in the sound film orchestra, and the good account of the limitations in reproduction imposed by the microphone and the rest of the recording and reproducing equipment, are in strong contrast with the poor exposition of the physics of recording. The author's brief treatment of the comparatively new electro-musical instruments, the *Ondium Martenot*, the trautonium and the Neo-Bechstein piano, is also good.

Dr. London's æsthetic judgment is sound, within its limitations. But he accepts far too easily the shackles of the average acoustic plumbing of the moment, and he neglects some of the most significant technical work of the decade. His imagination is misapplied in trimming the musician's mind and methods to fit the defects of the commercially available technique. He forgets that when babies and cradles do not fit, it is better to operate on the cradle. From this point of view, his interesting account of "microphone instruments", that is, "those constructed with a view to the special requirements of the microphone", is deplorable, as putting over-emphasis on this submission to the treason of the plumbers.

There is no valid ground for the assertion that an extension beyond 15,000 cycles per second of the frequency range reproduced would be of revolutionary æsthetic importance; the attention devoted to the sham 'stereoscopic' tone treatment of the French school is the more disproportionate because the conclusive experiments of the Bell Laboratories on binaural listening are not mentioned at all. It is firmly established by these experiments that true 'stereoscopic' listening, even with a very limited frequency range, is more satisfying than single-channel listening with a virtually complete frequency range. This omission emphasizes, too, the singular absence from the book of any reference to Stokowski, who has collaborated so fruitfully with the Bell Laboratories, not only on binaural listening but also on the utilization of the new powers which electrical reproduction puts at the disposal of the musician, in part-compensation for the disservices which it does him in other respects. Of all these disservices the greatest, in everyday practice, is the simple amplitude distortion which is not inherent in present technique, which is not mentioned by Dr. London, but makes a visit to any single cinema theatre definitely painful to a musicianly or acoustico-physical ear.

The author and the translator are responsible for some offences to the King's and the physicist's English; he uses the words "resonance", "tone" and "dynamic" inaccurately, as many people will.

It is perhaps too late to hope that the "recordist" may join the mortician, but it is not too late to kill the adjective "microgenic". The translator comes near distortion, for the ordinary reader, when he renders "Plastik" as "plastic", and goes beyond it for the ordinary viewer when he talks of a film called "President Vanisher".

The author's philosophy of film æsthetic is somewhat superficial, a fair recognition of the validity of expressionism in the music being marred by over-insistence on representationalism in the picture. To talk of the hand-written sound-track, with its vast possibilities, at some length is wise and discriminating; to talk of it as "quite unreal sound", "a magic realm created out of nothing" is nonsense. The Beethoven symphonies were "quite unreal sound", "a magic realm created out of nothing", in exactly the same sense; the orthodox score, the photographed sound track, and the hand-written track are all of them arbitrary notations containing, for the initiated, the prescription for producing real sound out of unreal sound.

Dr. London's book is the more welcome in giving so much enjoyable ground for disagreement; it is attractive, suggestive and educative. No one who recognizes the power of the sound film in modifying the taste of the citizens of to-day and to-morrow can afford to neglect it. Its attractions are enhanced by the many facsimile reproductions from film-music scores.

Science in Recent Years

The March of Science:
a First Quinquennial Review, 1931–1935. By Various Authors. Issued under the authority of the Council of the British Association for the Advancement of Science. Pp. viii+215. (London: Sir Isaac Pitman and Sons, Ltd., 1937.) 3*s*. 6*d*. net.

THIS book is the first of a new series of volumes wherein, it is intended, the advances made in the chief branches of pure science over a period of five years will be described in plain language by experts. These books are intended both for ordinary readers of scientific tastes and for those workers in any one branch of science who would like to learn with a minimum of trouble what is new and important in other branches. The style and difficulty is, in consequence, somewhere between those of the illustrated popular expositions and the learned reports for the specialist in his own science. Editors and publishers have attempted this kind of books in the past, sometimes with success, but it is good news that the Council of the British Association with its wide knowledge of the right contributors has now begun this work. The chief difficulty of such enterprises is, of course, in getting the best men to take the peculiar trouble which semi-popular exposition demands.

The present volume deserves a warm welcome from readers. It is rare that a permanent work, so homely in appearance, has such distinguished contributors. There are no illustrations. The price is modest. There are sixteen chapters or sections (varying from 2,500 to 6,000 words in length) by different writers, each of whom is distinguished in his own subject. Nearly all of these have done the journeyman work of compiling and writing satisfactorily, and some have done it very well. On the whole, the more eminent authorities have done their tasks better than the less. The sections on cosmical physics (Sir James Jeans), economic science (Sir Josiah Stamp), biochemistry (Sir F. Gowland Hopkins), and science and industry (Sir Frank Smith) are models of the thing required—apposite, informed, fair, well-expressed, neither too technical nor too popular for the readers envisaged. The important discoveries or developments in these subjects in the past five years are singled out and well described. The reader who has, perhaps, heard vaguely of some of these in talk can now know where the main interests of a diversity of subjects lie, what has been proved, what is still speculation, whither progress is tending and how good are prospects. Good also, although less distinguished, are the sections on geology (P. G. H. Boswell), geography (G. R. Crone), educational science (A. Gray Jones), agricultural science (J. A. S. Watson) and physiology (L. E. Bayliss).

It is chiefly in the sections on physics and physical chemistry that a bareness of treatment is revealed. Chemistry has sections on 'physical' and 'organic'. The former, however, should more properly have been called 'general'. The section is good as that, but it contains little of the advances in subjects like gas reactions, photochemistry, solution, catalysis. The writer on physics had a peculiarly hard task within his limits of difficulty and space. (Two sections might well have been allotted to this large field.) Unfortunately, however, he opened with an account of nineteenth-century physics, excellent in itself but largely irrelevant there, and so left himself too little space for some of the important revelations of the past five years. Dr. de Beer, on the other hand, has perhaps erred by excess of zeal. Compared with the other sections, his on zoology is too full, too well documented. But it cannot be criticized on other grounds.

A. S. R.

Preparation of Scientific and Technical Papers
By Prof. Sam F. Trelease and Emma Sarepta Yule. Third edition. Pp. 125. (Baltimore, Md.: Williams and Wilkins Co.; London: Baillière, Tindall and Cox, 1936.) 7*s*.

MANY useful hints on the composition of scientific papers, and methods of presenting observations and results logically and precisely, are given in this small volume. Much practice, combined with a sense of literary values, are required for the production of a scientific paper to satisfy all the canons of style which writers are expected to acknowledge. There are, however, many typographical and other conventions which every author should know; and it is particularly in guidance as to the use of these that this book will be helpful.

We note that in the list of abbreviations of common weights and measures, and elsewhere in the book, "cc" is given for cubic centimetre; but, as actually two words are abbreviated, "c.c." is the correct form. The classified titles of a number of scientific periodicals are given in another list, but we miss several British publications of greater importance than some others included. Under anthropology, *Africa* is included but not the *Journal of the Royal Anthropological Institute*; and among other omissions are: the *Quarterly Journal of Microscopical Science*, the *Journal of the Chemical Society*, and the *Philosophical Magazine*, while *Science Progress* is wrongly described as "Science Progress in the Twentieth Century". It is very difficult to make up a list of this kind, and impossible within the space of about nine pages to give more than a few representative titles of the many thousands of scientific periodicals now published. We suggest, however, that, before the next edition of the book is issued, the lists of journals grouped under headings relating to various branches of science should be submitted to competent authorities in each branch for revision.

The King's England:
a New Domesday Book of 10,000 Towns and Villages. (1) Enchanted Land: Half-a-Million Miles in the King's England. By Arthur Mee. Pp. xviii+291+65 plates. 7*s*. 6*d*. net. (2) Kent: the Gateway of England and its Great Possessions. By Arthur Mee. Pp. xii+506+65 plates. 10*s*. 6*d*. net. (3) Warwickshire: Shakespeare's Country. Edited by Arthur Mee. Pp. xi+308+49 plates. 7*s*. 6*d*. net. (4) Lancashire: Cradle of our Prosperity. Edited by Arthur Mee. Pp. viii+326+49 plates. 7*s*. 6*d*. net. (London: Hodder and Stoughton, Ltd., 1936.)

THESE four volumes are the first instalment of a survey of England by counties, which aims at describing in detail every town and every village in the country which is worthy of interest on account of its present economic or social importance, its past historical or personal associations, or its retention of features of artistic, antiquarian or cultural significance. The author has had the assistance of a body of expert helpers; and some six years have been spent in preparation. The time is not too long, as some ten thousand villages, it is said, have been visited. The collection of the photographs alone, if the illustration of the first four volumes is a fair sample, must have been a stupendous undertaking, especially as it is evident that on the whole a high standard has been attained.

Except in the first volume, which is a generalized epitome or survey of the topics with which the series deals as a whole, the arrangement of the material collected is that of the gazetteer. Each city, town or village visited appears in alphabetical order, the counties being characterized in a brief introduction, in which what is taken as the keynote is particularized, justified and expanded, though not at too great length. Kent, for example, is termed "the gateway of England", Warwickshire, "Shakespeare's country", and Lancashire, "the cradle of England's prosperity".

Yet in none of these volumes is this dominant note allowed to overshadow other interests. In Warwickshire, Birmingham and Coventry are not neglected, nor is Lancashire's industrialism allowed to obscure the relics of its ancient countryside or its interest for the student in Roman Ribchester and the wooden circle of Bleasdale. Mr. Mee is happiest, however, in rural Kent or Warwickshire, or in writing his general volume when he can roam about in the past among obscure villages with their ancient churches and family monuments, as well as their unexpected and their often surprising associations with some of the famous personages of history, social and literary no less than political.

Those of like tastes will roam with Mr. Mee with equal zest. It is a course of very mixed feeding, which will seem reprehensible to the formal historian and educationist. But it is very enjoyable.

School Certificate Chemistry
By A. Holderness and J. Lambert. Pp. x+414. (London: William Heinemann, Ltd., 1936.) 4*s*. 6*d*.

THIS is a pleasing book profusely illustrated by photographs and line drawings, the latter being unusually clear and instructive. The atomic and molecular theories are given careful attention and the authors have succeeded in making clear a section which most pupils often find rather difficult. The metals are treated in a somewhat original manner, the authors using a classification based on the electrochemical series instead of the usual periodic classification. The salts are grouped according to acid radicals instead of metals, the sulphates, for example, being described in the chapter on sulphuric acid.

Each chapter is provided with a set of questions, and there are general questions at the end of the book, preceding a list of atomic weights and a table of logarithms. A useful feature is the final chapter of twenty pages devoted to revision notes and definitions, which contains some good general advice to young pupils about to present themselves for examination. This is certainly a book which pupils and teachers alike will enjoy using. The consistent use of arrows instead of equals signs in equations will not commend itself to teachers, who find that this practice leads to carelessness in balancing equations.

Jan Swammerdam, 1637-80

By Prof. F. J. Cole, F.R.S.

JAN SWAMMERDAM was born at Amsterdam on February 12, 1637, and died there on February 17, 1680. He was the son of a prosperous apothecary, Johan Jacobsz Swammerdam, with whom he is frequently confused, and the grandson of J. Theodorus, who assumed the name of Swammerdam, and was born in the Dutch village of Swammerdam or Swadenburgerdam (now Zwammerdam) on the Old Rhine.

The pseudo-learned atmosphere of his father's private collection of rarities, which included minerals, fossils, plants, animals, manufactured and artistic curiosities and coins, the animal section forming about a sixth of the whole, could scarcely have been responsible for the rigorous scientific attitude towards natural knowledge which was characteristic of Swammerdam himself. His father intended him for the Church, but he embarked upon the study of medicine, only to be diverted from it by his passion for entomological research. Finally, however, he completed his medical course and graduated M.D. at Leyden in 1667. In the meantime, he had become friendly with his famous contemporaries Steno and de Graaf, but later his relations with de Graaf were embittered by a controversy on the structure of the genital organs. Also before graduation he had visited France, where he was befriended by Melchisedec Thévenot, and continued his entomological investigations. It was here that he publicly demonstrated the valves of the lymphatic vessels on June 19, 1664 (published 1667), but in this he was anticipated by another Hollander, Frederik Ruysch, who issued a detailed description of the valves in 1665.

On returning home, Swammerdam participated in the foundation of the private Amsterdam "College" of Medicine. This company of enthusiasts printed small volumes of transactions in 1667 and 1673, which are now exceedingly rare, and to which Swammerdam himself contributed. He was thus for the time committed to human anatomy, and experimented with methods of injection, inflation and preservation. He did not, however, invent *solidifying* coloured injection masses, as is generally stated, but he was responsible for the general adoption of the method by anatomists after his time. His first wax injection was carried out in van Horne's house in Leyden in 1666. It was probably in 1671 that he sent to the Royal Society, accompanied by descriptions and figures (published in 1672), his famous preparation of the human female genitalia. Arteries and veins had been injected with yellow and red wax, which acted as a preservative, and the whole was then dried. The Royal Society's collection was handed over to the British Museum in 1781, and this historic specimen was never again seen. Later, Swammerdam applied the injection method to the smaller invertebrates, and he succeeded in filling the blood vessels of a Lepidopterous larva from the heart by means of a capillary glass tube.

After an illness, Swammerdam abandoned human anatomy, and thenceforward devoted himself entirely to comparative anatomy, chiefly of insects. Such a devotion to science absorbed not only all his time and attention, but also was expensive, and his father penalized the neglect of a profitable profession by cutting off supplies. To mollify his angry parent, Swammerdam wasted much valuable time in cataloguing the family museum, and this catalogue, which was published in 1679, shows that the collection was not comparable with many others which existed in Holland at the time.

In 1673 Swammerdam came under the disturbing influence of Anthoinette Bourignon, and henceforward his interest in science began to decline. It flared up from time to time, but the process of extinction had set in. Finally, he convinced himself that the pursuit of learning was vain and even impious, and he died in an atmosphere darkened by the turmoils of an unbalanced mind. Nevertheless, it was during this period of strife that he completed his classic treatises on the honey-bee and the mayfly, working, as the rhetorical Boerhaave tells us, exposed bareheaded to the scorching heat of the sun and "dissolving into sweat under the irresistible ardours of that powerful luminary".

The early death of Swammerdam was not entirely responsible for the fact that the bulk of his work remained unpublished, for to his own indifference were added the apathy and neglect of his successors. The manuscripts passed first into the hands of Thévenot, who designed to publish them, but he died without discharging this important trust. After some vicissitudes, the papers were acquired by G. Duverney, the celebrated Parisian anatomist, who had already undertaken other charges of a similar nature, but lacked the desire to liquidate any of them. Finally, Boerhaave was moved to intervene, and in the subsequent proceedings he played an important and honourable part. He purchased the documents from Duverney, and published them under his own guarantee as two imposing folio volumes in Dutch and Latin in 1737–38, exactly a century after the birth of their author, but nevertheless not yet out of date ! It is painful to reflect that Swammerdam's own collection of preparations shared the common fate of the museums of his period, and, having failed to attract a purchaser, was dispersed. Unlike his great contemporaries, Malpighi and Leeuwenhoek, Swammerdam was not a fellow of the Royal Society ; but he corresponded with the Society, the archives of which include some material in his autograph. One genus (1826) and some ten species of insects have been named after him.

The picture which the evidence justifies us in forming of the personality of Swammerdam, is that of a man with an introspective and self-torturing mind which found expression sometimes in pompous and scornful criticism of others, but more often in the superfluous distractions of mysticism and spiritual exaltation. Add to this a consuming energy which produced, in some ten years before the age of forty, one of the most remarkable works in natural history which has ever been written, and also an indifferent physique wasted from time to time by fevers, and the result could only be a life which rapidly burnt itself out. His strength in research lay in observation and experiment. In reflection he was dangerous, and apart from the fact that he was a convinced and uncompromising opponent of spontaneous generation, which was incompatible with his belief in preformation, no important generalization can be associated with his name. No portrait of him is known to exist. That reproduced by Michelet and others is a forgery based on one of the lay figures in Rembrandt's "Anatomy Lesson" of 1632, the model of which could not have been Swammerdam.

The methods employed by Swammerdam in his finer work have been partly disclosed by Boerhaave. He used a simple dissecting microscope of his own design, made by Samuel J. van Musschenbroek, and very delicate dissecting instruments sharpened under the microscope. He was one of the first naturalists after Boyle to appreciate the importance of alcohol as a preservative, and was probably the first to make dissections under water, and to clear up an entomological preparation by dissolving out the fatty substances. The modern practice of preparing Lepidopterous larvæ for exhibition by pressing out the viscera and inflating and drying the skin was invented by Swammerdam.

In addition to various Parerga to be found in the works of T. Bartholini, sen., Thévenot, van Horne, Blasius, Boccone, Steno, the *Philosophical Transactions* and the works of the Amsterdam "College", Swammerdam published four major works during his lifetime. The first of these, an inaugural dissertation on respiration, was published in 1667 in Latin, and five other Latin editions appeared later. In 1927 the first edition was re-issued in Holland with a Dutch translation. This little treatise has considerable physiological importance. The discovery of the part played by air in respiration may here be recognized in one of its earliest phases, and the mechanism of mammalian respiration is ingeniously demonstrated by means of a pair of bellows containing the wind-pipe and lungs, in which the action of the bellows on the lungs can be observed through a glass window cut in the side. As pointed out by Patterson, this idea was adopted without acknowledgement by Mayow in 1674. In the interests of priority, it should also be recorded that Swammerdam's experiment had been published for thirteen years before Borelli issued the first volume of his "De Motu Animalium".

Swammerdam was among the earliest to test the effects of injecting the vessels of *living* animals, and his discovery that the mammalian lung sinks in water before it has functioned, but floats afterwards, has important medico-legal bearings in cases of suspected infanticide. Significant observations on clinical and chemical thermometers are also to be found in this remarkable thesis, and even topics foreign to its express purpose, such as the hermaphroditism and reciprocal union and fertilization of snails, are not excluded.

Swammerdam's first entomological publication, which later formed a part of the "Biblia Naturæ", was his "General History of Insects". It appeared in 1669 in the Dutch language, and was followed by five other French and Latin editions. A few years later, in 1672, the work on the uterus was issued, and went through eight editions, all of them in Latin. It includes the polemic against de Graaf, but is important from the point of view of anatomical injections and the preformation doctrine.

The treatise on the mayfly was first published in 1675 in Dutch—six years after Malpighi's treatise on *Bombyx*—but only two other editions, in English and French respectively, appear to have been printed. To Anthoinette Bourignon the mayfly was a "little beast which lives for only a single day, and throughout that time endures many miseries". She gave, however, a grudging consent to the printing of the book, but implored Swammerdam to devote himself in the future to the more serious things of eternity. In this expansive and verbose work Swammerdam followed the lead of Servetus, and undertook the dubious task of establishing an ethical system which united the diverse interests of biology and divinity. In spite of the fact that it had a numerous following, amongst whom may be mentioned Lesser in Germany and Kirby and Spence in England, insecto-theology, as it was called, fell an inevitable victim to its own disruptive elements. The biology of the work, however, greatly diluted as it is, shows us Swammerdam at his best. He appears to have started work on the mayfly as early as 1667. The anatomy of the small nymph is beautifully worked out, and in this respect Swammerdam is clearly superior to Malpighi. In addition, the curious life-history, in which the brevity of the adult stage is contrasted with the exceptionally long larval period, is laid bare for the first time. This work is also included in the "Biblia Naturæ".

The posthumous "Bible [not Book] of Nature" owes its name probably to its sponsor Boerhaave, and the detailed and accurate plates are the work of an artist employed by the author. One of the Ephemera plates, however, is signed "Auctor del". In all, eight editions were published, including German, French and English translations. It is impossible in this brief notice to refer to more than a few of the topics which are investigated in this stupendous work. Its plan, based on selected types, is monographic, comparative and experimental, and it is undoubtedly the foundation of our modern knowledge of the structure, metamorphosis and classification of insects. In addition, there are valuable observations on Crustacea, Mollusca and the life-history and anatomy of the frog in both larval and adult stages. Swammerdam spent some five years on the hive-bee, dealing with the anatomy, life-history and general economy of that much investigated animal, and his account of it is the most trustworthy and comprehensive we have had from any one man. It would, in fact, rank high even if judged by modern standards. In 1668 Swammerdam had already discovered by skilful dissection that an insect larva, pupa and imago may *at one stage* of the life-cycle exist simultaneously one within the other like a nest of boxes, and he had also studied experimentally the conditions which induce and regulate moulting and metamorphosis. His consequent assumption that no new parts are formed, and that the perfect insect is there *all the time*, led him to adopt the Preformation doctrine, the long and evil reign of which lies so heavily on his reputation. Swammerdam severely criticizes Harvey's views on metamorphosis, esteeming him at "little less than nothing", and stating that his work on generation contains almost as many errors as words. Harvey's philosophy of generation may have been, as Vallisneri says, "encrusted with Aristotelian pitch and heavy with rust", but it was the deadly blight of Preformation that stopped the clock.

Swammerdam accidentally stumbled upon the mimetic resemblance of certain Diptera to bees, and he found that some Lepidopterous egg masses might give rise to flies instead of caterpillars, which is the earliest record of egg parasites. He observed also in the case of the frog the first cleavage of the ovum, and noted the cellular structure of later stages. He admits, however, that blood corpuscles had been known for "some years" before he saw them, but does not give the source of his information, which could scarcely have been Leeuwenhoek. He certainly found the oval blood corpuscles of the frog before Leeuwenhoek. His ingenious neuro-muscular preparation (1668) by which he studied the relation of muscle and nerve, and the nature of muscle contraction and the nerve impulse, enabled him to refute the current belief that muscular action was due to a material substance reaching the muscle via the nerves, and in his experiments on the contraction of the heart and muscle he invented a form of plethysmograph. These results alone would entitle him to be regarded as one of the founders of experimental biology. But to the discoveries which are to be found in the "Biblia Naturæ" there is almost no end.

Chemical Exploration of the Stratosphere*

By Prof. F. A. Paneth

OUR prospect of finding differences in the chemical composition of the air is, of course, better the higher the sample is obtained in the stratosphere. An important part of the whole research is therefore the collection of air samples from great altitudes. For this purpose, sending up automatic devices in unmanned balloons is the most efficient method. Aeroplanes cannot attain sufficiently high altitudes; even Squadron Leader F. R. D. Swain in his record flight last September reached only 15 km., and the inconveniences of an airtight suit preclude complicated scientific operations. Balloon ascents in closed gondolas, as introduced by A. Piccard in 1931, give more freedom for observations, and can attain greater heights. A year ago, Capt. Stevens and Capt. Anderson in a stratosphere flight arranged by the National Geographic Society and the U.S. Army Air Corps reached 22 km.; but it cannot be said that the scientific results of the expedition justified the immense costs. The varying conditions of the atmosphere make numerous observations necessary, and only the cheap flights of sounding

* *Continued from p. 182.*

balloons can be repeated frequently enough; moreover, they can ascend far higher than manned balloons. (Heights of more than 30 km. have been recorded.) Fig. 2 shows the altitudes so far

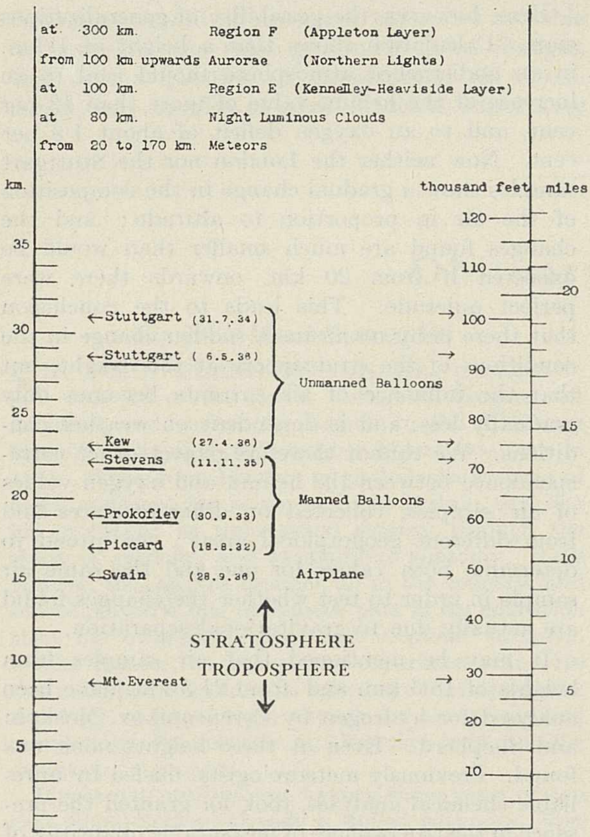

Fig. 2.

CHART OF STRATOSPHERE FLIGHTS. AIR SAMPLES WERE OBTAINED ON THOSE WHICH ARE UNDERLINED.

reached by the most successful flights of aeroplanes, manned and unmanned balloons. The flights from which air samples have been brought back are underlined. A number of other air samples collected by sounding balloons are not recorded in the figure; the heights attained can be seen in Table 3.

For the automatic sampling quite a simple device is sufficient. The one used in the joint work of the Meteorological Office of the Air Ministry, and Dr. Glückauf and I working at the Imperial College of Science and Technology, is represented in Fig. 3. A detailed description has been given by Mr. L. H. G. Dines of the Upper Air Section of the Meteorological Office, who launched the balloons from Kew Observatory[1]. The device comes into operation after the sounding balloon has burst at the top of its flight; an extension of an evacuated glass bulb is then broken, and air is sucked in while the vessel, attached to a parachute, begins to fall; after an interval of 10–15 sec. the extension is sealed again. In Fig. 3 on the right-hand side are to be seen the parachute, the bamboo cage and the aluminium cylinders which contain the glass vessel and a Dines barothermograph; on the left side are the glass vessel (volume about 500 c.c.), and the electrical arrangement for breaking the extension and for sealing the bulb again; this latter is effected by means of a heating coil which surrounds the lower part of the glass stem and fuses a particular kind of sealing wax contained inside. If the mechanism functions satisfactorily, the pressure of the air inside the vessel should correspond within certain limits to the highest value of the barographic record.

These flights have been in progress since 1935. From the first results, published a year ago[2], it was concluded that up to 18 km. no definite change in the chemical composition of the stratosphere occurred, but that at a height of 21 km. the relative amount of the light gas helium is already distinctly increased. During the past year, this has been confirmed by further successful flights reaching more than 23 km.[3] Similar investigations

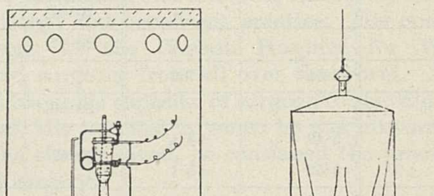

Fig. 3.

APPARATUS FOR SAMPLING STRATOSPHERE AIR.

have lately been carried out by Prof. E. Regener in Stuttgart[4], using larger balloons; in his samples, one from a height of more than 28 km., he determined the oxygen content and found deficits, in good agreement with the helium surpluses detected in the London flights. The only two air samples obtained by manned stratosphere balloons also confirm our finding: a sample collected over Russia by Prokofiev in 1933 at a height of 18·5 km., and analysed by A. A. Čerepennikov and by A. B. Moskvin, showed no variation in its composition[5]; but the air brought back by Capt. Stevens from 21·5 km., and analysed with great accuracy by M. Shepherd[6] of the National Bureau of Standards in Washington, revealed a slight oxygen deficit.

TABLE 3.
HELIUM AND OXYGEN CONTENT OF THE ATMOSPHERE AT VARIOUS ALTITUDES.

Height in km.	Helium[2,3]		Oxygen	
	Per cent by vol.	Variation (per cent He)	Per cent by vol.	Variation (per cent O_2)
0	$5 \cdot 27 \times 10^{-4}$	0	20·945[6] 20·92[4]	0 0
9–16·8			20·92[7]	0
14·5			20·89[4]	−0·14
16·7	5·30	+0·5		
18·5	5·31	+0·7	20·95[5] 20·84[4]	0 −0·38
19			20·87[4]	−0·24
21	5·64	+7·0		
21·5			20·895[6]	−0·24
22	5·49 5·53	+4·1 +5·1	20·57[4]	−1·7
23·4	5·49	+4·2		
24			20·74[4]	−0·86
28–29			20·39[4]	−2·5

In Table 3 all reliable data about the helium and oxygen content of stratosphere air are brought together. In addition to the results already mentioned, the figure found by Lepape and Colange[7] for the average oxygen content of samples collected between 9 km. and 16·8 km. is also included; they observed no deviation. According to the same authors the helium plus neon content at this height varies considerably (as much as 57 per cent), and on the average is increased by 27 per cent; the method applied was, however, not reliable. Our results show the constancy of the helium, and therefore *a fortiori* the neon, content at these heights within one per cent.

The deviations in the helium and oxygen content of the higher layers of the stratosphere, revealed by the figures in Table 3, from those in the troposphere, are in the direction to be expected if at a height of about 20 km. winds are no longer efficient enough to ensure a complete mixing of the atmospheric gases. The 'light' gas helium is present in a higher, the 'heavy' gas oxygen in a lower, percentage. The difference is more marked in the case of helium; this is in good accord with the greater density difference between helium and the main atmospheric gas, nitrogen (see Table 2).

Here, however, the possibility of generalizations ends. Calculation shows that a height of 1 km. in an undisturbed atmosphere should lead to an increase of the helium value of more than 13 per cent, and to an oxygen deficit of about 1·6 per cent. Now neither the London nor the Stuttgart samples show a gradual change in the composition of the air in proportion to altitude; and the changes found are much smaller than would be expected if from 20 km. onwards there were perfect quietude. This leads to the conclusion that there is by no means a sudden change in the conditions of the stratosphere at this height, but that the influence of air currents becomes only gradually less, and is dependent on weather conditions. We cannot therefore expect exact correspondence between the helium and oxygen values of air samples, collected on different dates and from different geographical areas; we intend to determine both values for one and the same air sample in order to test whether the changes found are actually due to gravitational separation.

It may be mentioned that air samples from heights of 18·5 km. and from 21·5 km. have been analysed for hydrogen by Čerepennikov, Moskvin and Shepherd. Even at these heights none was found. Previously meteorologists, misled by unreliable chemical analyses, took for granted the presence in the troposphere of measurable quantities of hydrogen, and demonstrated by calculations that the upper part of our atmosphere should therefore consist almost entirely of hydrogen. Some even went so far in hypothetical speculations as to postulate the presence there of a still lighter element, christened 'geocoronium' or 'zodiakon'. This, and particularly the 'hydrogen sphere', is still mentioned in many text-books. G. Ch. Lichtenberg, professor of physics in Göttingen a century and a half ago, must have had similar cases in mind when he wrote: "Perhaps Hamlet is right that there are more things in heaven and earth than are dreamt of in our philosophy; but on the other hand it may be said that there are a good many things in our natural philosophy books of which neither in heaven nor on earth any trace can be found."

When we started work two years ago on the helium content of stratosphere air, it was quite unknown whether it would be possible to reach a layer where any variations from the composition of ordinary air occur. The only accurate figure about stratosphere air then available, the oxygen analysis of air from 18·5 km. height, collected and analysed by the Russian investigators, showed not yet the slightest difference from ordinary air. Since last summer, we have been certain that from about 20 km. upwards the composition of air changes to a measurable extent. Much further work will be necessary before we are able to formulate the rules governing these changes. But as the question of stratospheric air movements may be also of some practical importance for weather forecasting and for aeronautics, we hope to continue, and to extend, our researches.

[1] L. H. G. Dines, *Quart. J. Roy. Meteorol. Soc.*, **62**, 379 (1936).
[2] F. A. Paneth and E. Glückauf, NATURE, **136**, 717 (1935).
[3] Details of the new flights will be published later.
[4] E. Regener, NATURE, **138**, 544 (1936).
[5] Report of the Central Geophysical Observatory U.S.S.R. Short abstract of the Russian publication in NATURE, **133**, 918 (1934).
[6] M. Shepherd, private communication.
[7] A. Lepape and G. Colange, *C.R.*, **200**, 1871 (1935); NATURE, **137**, 459 (1936).

Obituary Notices

Sir John Bland-Sutton, Bt.

SIR JOHN BLAND-SUTTON, BT., president in 1923–25 of the Royal College of Surgeons of England, and consulting surgeon to the Middlesex Hospital, who died on December 20 last, was born in 1855. Since John Hunter, no pathologist-surgeon of equal eminence has arisen in Great Britain, and like his prototype he approached surgery through the study of anatomy and comparative anatomy. Like Hunter, too, he was brought up in the country, and school played a less prominent part in his education than his own sharp eyes and sceptical curiosity. Unlike Hunter, he was not an experimentalist. He was more preoccupied with naked-eye form than with histology or physiology, though he always studied morphology in relation to function and to the evolutionary process.

It was not until he was twenty-three years of age that Bland-Sutton, already a skilled naturalist, first determined to be a surgeon. Poverty in youth teaches a man that independence, the power to help others, free choice, and the avoidance of jarring contacts are unattainable unless one does something that the world needs and is willing to pay for. In surgery Bland-Sutton found a field for his talents and for applying his mastery of anatomy and pathology. He entered as a student of the Middlesex Hospital in 1878, and in the following year was appointed demonstrator of anatomy. As an anatomical teacher he achieved great popularity, and in 1886 he was appointed assistant surgeon, becoming surgeon in 1905 and consulting surgeon in 1920. Throughout life, he remained devoted to the Middlesex Hospital, to which in 1914 he presented the complete pathological institute which bears his name. It was significant of his forward outlook that the space allotted to the museum in the new building was reduced so that more scope could be given to the experimental and histological laboratories.

In 1896, Bland-Sutton was appointed surgeon to the Chelsea Hospital for Women, and it was in gynæcological surgery that he made his name. For years this branch of surgery was practised by physicians—a curious anomaly having its roots far back in history. Spencer Wells and his successors at the Samaritan Hospital had broken through the tradition, and some obstetric physicians were good surgeons, *vixerunt fortes ante Agamemnon*, but the main credit for bringing pelvic surgery up to the level of general surgery unquestionably belongs to Bland-Sutton. He more than any man disestablished the 'couch-invalid' formerly seen in so many families—generally a woman with fibroids, an ovarian tumour, or the sequelæ of pelvic inflammation. Striding into this field where the crop had been ripening through many tedious years of invalidism and inaction, he rapidly acquired a very large and beneficent practice. His operating afternoons at the Chelsea Hospital for Women attracted surgeons from all over the world. At the same time, in his capacity of surgeon to the Middlesex Hospital, the hospital in which he was nurtured and which he always loved, he continued the practice of general surgery.

As an operator, Bland-Sutton was rapid and safe, though some critics considered him lacking in the refinements of technique. His results were excellent. Surgeons, like the clergy, may perhaps be divided into two classes, ritualists and evangelicals. Some love complicated instruments and elaborate technique; Bland-Sutton liked to reduce his instrumental and aseptic outfit to the minimum essential for the job in hand. Moreover, as a pathologist he realized that Nature is the real surgeon, while the surgeon is a kind of 'plumber's mate' to Nature. He never wasted time in doing things that Nature would do better herself. Perhaps in sewing up the abdominal wall with a single layer of sutures he sometimes trusted her too much.

Bland-Sutton had a vigorous common-sense mind which always led him to seize on the essentials of a subject and to press direct to a conclusion which was generally the right one. His mental vigour always seemed to maintain a constant level, so that in the spare quarters of an hour which most men waste, he could add a few lines to any paper he was writing. *Nulla dies sine linea* was a favourite quotation. His mental energy demanded satisfaction in constant work, and needed no whipping up to the task. Few men have done more work in a lifetime, and few have done it better. He said he could only learn by the eye, and noted in himself an entire absence of the mathematical faculty, nor I think did music appeal to him. His letters, always brief and pointed, were written in a clear and unhurried hand, and so far as I know he never employed a secretary, a typewriter or a dictaphone. From his boyhood's intensive Bible lessons, for his aunt intended him for the Church, and from the study of Shakespeare, he derived a distinctive literary style, concise, arresting, and seasoned with an occasional archaism or blunt Anglo-Saxon word. It may have been the foundation of his friendship with Kipling that both men were students of the art of expression.

Bland-Sutton once said to me in reference to a very large text-book : "It is very easy to write a big book and very difficult to write a small one," surely a salutary doctrine for these days. The truth was illustrated in Bland-Sutton's classic book on tumours, which has gone through many editions. In it he brought into small compass and proper interrelation a crowd of unorganized facts, and vivified the subject for generations of students. He would have nothing to do with dull half-tone illustrations, and insisted on wood-cuts. I still remember the interest and relief with which I read this book, so different from some of the woolly and verbose text-books of its day.

Bland-Sutton's mind can also be studied in his earlier book of 1890, "Evolution and Disease", which broke the new ground of comparative pathology. He wished to indicate that "there is a natural history of disease, as well as of plants and animals". "We shall find conditions which we regard as abnormal in man presenting themselves as normal states in other animals." "There has been an evolution of disease *pari passu* with evolution of animal forms." "I quickly saw that the manifestations of disease were regulated by the same laws which govern physiological processes in general." Such are some of his conclusions, illustrated by a wealth of detailed examples derived from his studies as pathologist to the Zoological Society. A subject of special interest to him was the comparative pathology of the reproductive organs in animals, and in 1892 he received the Jacksonian Prize of the Royal College of Surgeons for a study of diseases of the ovaries and uterine appendages, which probably determined the direction of his surgical activities.

For some years Bland-Sutton was an active member of the old Obstetric Society, in which discussion was at that time conducted with gloves of minimum weight. There is much to be said for frank discussion, but the hand of the dominant seniors was heavy upon their juniors. A young man read before the Society a paper explaining a novel condition of which he had found an example in a hospital museum. Patronizing criticism followed until Bland-Sutton got up. He said : "Some years ago I was a member of a committee appointed to consider this specimen. We could come to no conclusion about it and I said that it should be placed in a museum, and that some day light would be thrown upon it. Gentlemen, that light has come." Such generous feeling for his juniors was habitual with Bland-Sutton, as the writer—for some years his assistant surgeon at the Middlesex Hospital —can testify from personal experience.

Though in youth he must have been a great reader, Bland-Sutton's regard for books was not a very high one, and he always strove for first-hand knowledge of any subject which interested him. His library was kept to an absolute minimum, partly by the incineration of intruders as soon as they had been perused. His interest in general literature was not keen, though Egyptian and Persian archæology fascinated him. The Bible, Nature, Shakespeare, the world of men and women (for he was a great traveller), were his educators, and for his strong personality these sufficed. It was not only in his profile, but in himself also that something Napoleonic could be detected. It showed in his intense industry, his coolness in crisis, in his quick grasp of the essentials of a problem, in the rapid translation of decision into action, and in a certain aloofness of personality. His nature was kindly and generous. Fortune allowed him to enjoy the golden age of Victoria and to exercise for years a splendid hospitality in the replica of a hall which a king of Persia had built for himself. In his consulting room was an Egyptian frieze representing the weighing of the soul after death in the courts of Osiris. It was his reminder to himself of his mortality, and of the ethical standards surviving from his Puritan training.

I cannot conclude without a reference to the mutual devotion which for so many years bound Sir John to Lady Bland-Sutton, who survives him.

W. SAMPSON HANDLEY.

Prof. J. A. MacWilliam, F.R.S.

BY the death on January 13, at the age of seventy-nine years, of Prof. J. A. MacWilliam, the University of Aberdeen and the medical sciences have lost one who by devoted service to his Alma Mater and untiring zeal in scientific investigation had become known to many at home and abroad. He had held the regius chair of physiology at Aberdeen for forty-one years, from 1886 until 1927.

Prof. MacWilliam's chief contribution to scientific medicine was the discovery that the peculiar condition known as fibrillar contraction of the heart consisted of a lack of harmony in contraction and relaxation of the minute bundles of muscle fibres of which the walls of the heart are composed. He showed that fibrillation is not due to interference or destruction of some co-ordinating nerve centre; but that it is brought about by what he described as a "rapid succession of inco-ordinated peristaltic contractions". He also showed clearly the relation of the refractory period to this disturbance. It is not without interest to note that the real significance of his work was not fully recognized until comparatively recent times. The work had its inspiration in the famous school of Ludwig at Leipzig, which, in the eighties of last century, was a Mecca for many of the younger physiologists on both sides of the Atlantic. Bowditch of Harvard, Gaskell of Cambridge, MacWilliam and others were at that time actively engaged in demonstrating those peculiar properties of heart muscle upon which cardiac rhythm depends.

For several years, MacWilliam's indifferent health interfered with intensive original research, and it was not until 1913 that a further series of important papers appeared on the measurement of blood pressure in man. These investigations were the subject of a comprehensive discussion which appeared in *Physiological Reviews* in 1925. There are other publications to which reference might be made, but those mentioned indicate the extent of his work and the high estimate which has been placed upon it. In 1916 MacWilliam was elected a fellow of the Royal Society, an honour which brought satisfaction to many of his colleagues and students.

It is perhaps as teacher and lecturer that MacWilliam will best be remembered. Gifted with a clear and lucid style, he could present, with but the slightest reference to notes, the most difficult aspects of his subject. As a lecturer he had few equals; every lecture was excellently arranged, clearly delivered and full of interest and incident. To those who had the privilege of knowing him intimately, Prof. MacWilliam revealed a new depth and richness of character which made one realize the greatness of his personality. The experience of the years—and they were not without their share of sorrow and suffering—had produced a wonderful combination of philosophical insight and critical scientific judgment.

By his personal qualities, always gracious, never unkindly critical, ever sympathetic, Prof. MacWilliam endeared himself to many generations of Aberdeen students. His charm of manner, his constant kindness and courtesy, won for him the affectionate regard of all who knew him intimately. In the world of science his name has an enduring place; in the hearts of his friends his memory will for long be cherished.

E. W. H. CRUICKSHANK.

Sir Halley Stewart

SIR HALLEY STEWART, whose death at the advanced age of ninety-nine years occurred on January 26, was a generous supporter of scientific research. One of his outstanding benefactions was the founding of the Halley Stewart Laboratories for Physics Research at Hampstead, which now forms a post-graduate school of the Physics Department of King's College, London. These laboratories were in the first instance put at the disposal of the College in 1932 for the special use of Prof. E. V. Appleton, whose radio researches in the college buildings in the Strand had been greatly hampered by the electrical interference caused by adjacent machinery. The premises in Hampstead, which were formally opened by Lord Rutherford, provided a fully equipped electrical research laboratory as well as a residence above, for the professor of physics. During the years 1932–36, Prof. Appleton and his students were able to continue unhampered their exploration of the properties of the higher atmosphere using radio waves emitted from the roof of King's College and received at Hampstead. Since Prof. Appleton's translation last year to Cambridge, the Halley Stewart Laboratories have been directed by the present Wheatstone professor, Dr. C. D. Ellis, whose researches lie mainly in the field of radioactivity.

WE regret to announce the following deaths:

Prof. Stanley R. Benedict, professor of biochemistry in Cornell University Medical College, on December 21, aged fifty-two years.

Prof. Philip E. Browning, formerly associate professor of chemistry in Yale University, an authority on the rare elements, on January 2, aged seventy years.

News and Views

New Year Honours

THE following names of scientific workers and others associated with scientific work appear in the list of New Year honours conferred by the King, which was published on February 1. *Baron:* Sir Harry McGowan, chairman of Imperial Chemical Industries, Ltd. *Order of Merit:* The Right Hon. H. A. L. Fisher, warden of New College, Oxford, in recognition of his eminent position as an historian and of his services to literature. *K.C.B.:* Mr. H. T. Tizard, rector of the Imperial College of Science and Technology. *Baronet:* Mr. P. Malcolm Stewart, late Commissioner for the Special Areas (England and Wales). *K.C.M.G.:* Mr. F. A. Stockdale, agricultural adviser to the Secretary of State for the Colonies. *D.B.E.:* Lady (Juliet Evangeline) Williams, honorary treasurer, Queen Charlotte's Anæsthetic Fund, and honorary secretary of the Joint Council of Midwifery. *Knights Bachelor:* Dr. J. A. Arkwright, member of the Agricultural Research Council; Prof. J. C. G. Ledingham, director of the Lister Institute, London, professor of bacteriology, University of London; Lieut.-Colonel A. G. Lee, Engineer-in-chief, Post Office Engineering Department, General Post Office; Dr. E. K. Le Fleming, chairman of the Council of the British Medical Association, a member of the General Council of Medical Education and Registration of the United Kingdom; Mr. C. G. Trevor, Indian Forest Service, Inspector-General of Forests, and president of the Forest Research Institute and College, Dehra Dun.

C.B.: Dr. L. D. Barnett, lately keeper of Oriental printed books and manuscripts, British Museum; Mr. F. C. Cook, chief engineer, Roads Department, Ministry of Transport; Dr. M. F. Lindley, comptroller general of patents, designs and trade marks and comptroller of the Industrial Property Department, Board of Trade. *C.S.I.:* Mr. F. Anderson, Indian Service of Engineers, chief engineer and joint secretary to the Government of the United Provinces in the Public Works Department, Irrigation Branch, United Provinces; Mr. T. B. Tate, Indian Service of Engineers, chief engineer and secretary to the Government of the Punjab in the Public Works Department, Irrigation Branch, Punjab. *C.M.G.:* Mr. R. Marrs, principal, Ceylon University College. *C.I.E.:* Mr. C. E. L. Gilbert, Indian Forest Service, chief conservator of forests, Bombay Presidency, Bombay; Dr. D. Penman, chief inspector of mines in India, and lately principal, Indian School of Mines, Dhanbad; Rao Bahadur Tiruvadi Sambasivaiyer Venkataraman, Indian Agricultural Service, sugarcane expert, Imperial Cane Breeding Station, Coimbatore; Mr. H. L. O. Garrett, Indian Educational Service (retired), lately principal, Government College, Lahore, Punjab; Dr. G. C. Ramsay, deputy director of the Ross Institute of Tropical Hygiene, London School of Hygiene and Tropical Medicine. *C.B.E.:* Mr. C. Gillman, chief engineer, Railways, Tanganyika Territory; Mr. A. E. Hamp, chief engineer, Kenya and Uganda Railways and Harbours; Mr. G. Jeffrey, member of the Agricultural Bureau, State of South Australia; Mr. D. Mackay, for services in connexion with scientific exploration and survey in the interior of Australia; Mr. H. A. Lewis-Dale, deputy director of Works and Buildings, Air Ministry; Mr. A. G. H. White, lately librarian to the Royal Society.

O.B.E.: Rai Bahadur Mathura Prasad Bhola, lately deputy conservator of forests, United Provinces; Mr. C. Chaffer, principal technical officer, Compass Department, Admiralty; Mr. R. B. Crusher, assistant director of surveys, Palestine; Prof. S. M. Dixon, lately member of the Safety in Mines Research Board; Mr. P. E. L. Gethin, chief surveyor and director of civil aviation, Tanganyika Territory; Mr. B. Hart, honorary consulting radiologist to the Doncaster Royal Infirmary; Mr. E. W. D. Jackson, Indian Service of Engineers, executive engineer (irrigation), Meiktila Division, Burma; Mr. H. S. Kingsford, assistant secretary, Society of Antiquaries of London; Mr. R. H. Locke, superintendent, Horticultural Operations, New Delhi; Dr. G. H. Pethybridge, lately mycologist and assistant director, Plant Pathological Department, Harpenden; Mr. E. A. Smith, chief technical officer for fuel, H.M. Office of Works and Public Buildings; Mr. J. G. Strickland, assistant director of surveys, Uganda Protectorate. *M.B.E.:* Surendra Nath Chakravarti, Indian Service of Engineers, municipal engineer, Delhi; Mr. R. McKintosh, Indian Service of Engineers, executive engineer, Public Works Department, Madras; Mr. C. MacQuarie, agricultural surveyor, Medical Department, Tanganyika Territory; Mr. W. E. Pereira, Bombay Forest Service, personal assistant to the chief conservator of forests, Bombay Presidency, Bombay; Major H. C. Phillips, Indian Medical Department, superintendent of the Punjab Vaccine Institute, Lahore, Punjab; Mr. J. H. Smith, principal, Oaklands Farm Institute, and agricultural organizer for Hertfordshire.

History and Significance of the Electron

DR. KARL T. COMPTON, while professor of physics in Princeton University, performed and inspired a great deal of work on the phenomena of the electric discharge in gases, on the emission of electrons from surfaces and on ionization by electron impact. He is now president of the Massachusetts Institute of Technology. His article on "The Electron: its Intellectual and Social Significance" published as a supplement in this issue (p. 229) contains a survey, written in general terms, of the development of our knowledge of the electron since its discovery at the end of last century. The discovery of the electron, and the application of the electron ideas, first to gas discharges, then to radioactivity, spectroscopy and atomic structure, opened a most rapid advance in physical science, leading up to contemporary views of atomic structure and of chemistry. Applied to technical sciences, particularly in the communication industries, the electron has assumed great commercial and social significance.

Prof. C. N. Hinshelwood, F.R.S.

MR. C. N. HINSHELWOOD, who succeeds Prof. Frederick Soddy as Dr. Lee's professor of inorganic and physical chemistry at Oxford, is a leader of physical chemistry in Great Britain. Still in his thirties, he has made a great reputation by his work on gas reactions. He was formerly fellow of Balliol College and University lecturer in chemical dynamics. He is a fellow of Trinity College, a fellow of the Royal Society, an honorary doctor of science of Dublin and a delegate of the Clarendon Press. He is the head of the Balliol and Trinity Colleges Laboratories, and is the first member of this school of physical chemistry to become professor at Oxford. He is a man of wide interests outside his professional work and, in particular, an expert linguist. At Oxford, professorships are attached to particular colleges. In the ordinary way Prof. Hinshelwood should migrate to, and become a fellow of, Exeter College on his appointment. It has happily been arranged, however, that he remain at Trinity College, and in charge of the laboratories there, until an official University institute of physical chemistry be built in the Parks.

Science in the U.S.S.R.

REFERENCES were made in NATURE of January 23 (p. 142), and January 30 (p. 185) to the position with regard to the International Congress of Genetics which was to have been held in Moscow this summer. A request for further information was sent to His Excellency the Russian Ambassador, who has favoured us with a statement on the recent meetings of the Lenin Agricultural Academy (see NATURE, Jan. 30) and on the International Congress of Genetics. Dealing with the latter, the statement is as follows:

"As to the postponement of the Genetics Congress, it is a fact that this was due to requests received by the organisers of the Congress from a number of scientists who wished to have more time for preparation for it. The sole motive for such a postponement was therefore the desire to secure the very best preparation for the Congress and the widest possible participation in its work by scientists of different countries. One thing must be borne in mind in any discussion of the problems of scientific development in the U.S.S.R. The U.S.S.R. is a country of planning. The whole economy of the country, and also the various branches of its cultural and scientific activities are regulated by a definite State plan. Science is planned, not, of course, in the sense that every minute detail of scientific research, etc., is laid down beforehand in a Government Department. That would be ridiculous. But science is planned in the sense that the broad outlines of its development are brought into line with the most urgent requirements of practical life. The prevailing view in the U.S.S.R. is that science must not consider itself a demi-god with the right to choose its own course without any reference to the needs and requirements of the people. On the contrary, the primary object of science is to serve as faithfully as possible the needs of the people, and, indeed, of humanity. Some scientists in foreign countries seem to be inclined to confuse the planning of science, in the above sense, with a lack of scientific freedom. But this is a cardinal error. The planning of science, like planned economy, prevents the waste of human energy and endeavour, and makes it possible to concentrate the greater part of scientific effort on the points of real need of the people and of humanity. The great advantages of such a system are clearly shown by the enormous advance of science in the U.S.S.R. during post-revolutionary years. Indeed, every unbiased observer will testify to the very great prospects for scientific development which exist in the U.S.S.R., such as can be found in scarcely any other country."

The United States Floods

THE catastrophic inundation of the valley of the River Ohio, which was referred to in NATURE of January 30 (p. 185), has since assumed even more alarming proportions and threatens to overwhelm in a comprehensive deluge the whole of the Mississippi Valley from the town of Cairo (Illinois) at the junction with the Ohio River right down to the Gulf of Mexico. The flood waters from the latter river are moving onwards, unchecked and uncontrolled, at the rate of 80–90 miles per twenty-four hours. The extent of country involved can be seen from the accompanying map. At the moment of writing, Cairo is just commencing to receive the crest of the wave, which is expected to culminate in a level of 62 ft. Thence it will pass on through Memphis (Tennessee), Vicksburg and Natchez (Mississippi) to Baton Rouge and New Orleans (Louisiana). In the Ohio Valley there has been left a track of widespread ruin and desolation, with the water still standing 12 ft. deep in the streets of Evansville, just below Louisville. Surveying the disaster at the week-end, the American Red Cross reported 400 people dead, 800,000 homes flooded, more than a million people still homeless and more than a quarter of a million marooned in the upper floors and roofs of their houses or other refuges. The chairman stated with every justification that the American nation is faced with the gravest emergency since the Great War. The material damage is estimated at 400 million dollars (£80,000,000). Not less important is the denudation of the valley, from which some 3,000,000 tons of fertile soil have been swept down-stream by the force of the current.

ORDERS have been issued from Washington to the Army to prepare plans for the evacuation of the entire civilian population within an area extending fifty miles on each side of the Mississippi, in case of a collapse of the levees with which the river banks are topped. Already 60,000 people have moved to

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higher ground in Arkansas and 30,000 have left their homes in Missouri. Disease and privation have followed on the heels of the flood. A state of quarantine has been declared in Louisville, where typhoid is prevalent, and 200,000 persons have been inoculated. An explanation put forward to account for the magnitude of the disaster is that the Ohio has received as much run-off from rainfall within a fortnight as it usually receives in six months, by reason of the mildness of the season, which has allowed mountain streams to run freely instead of the flow being retarded by the formation of ice and snow, which normally melts slowly during the spring months. Meanwhile, though it is reported that rain has continued to fall heavily in the afflicted area, it is hoped that the worst is past, and that the serious forebodings hitherto entertained will not be realized.

Recent Solar Activity and Radio Fadings

AMONG the recent solar phenomena, now betokening a considerably disturbed sun, may be noted two large groups of sunspots and a smaller one of special interest. Particulars of these groups are as follows:

	Date on Disk	Central Meridian Passage	Latitude	Maximum Area
(1)	January 17–30	January 24·2	19° S.	1500
(2)	January 19–Feb. 1	January 26·1	20° N.	600
(3)	January 24–Feb. 6	January 31·2	11° S.	1500

Areas are expressed in millionths of the sun's visible hemisphere.

Group (1), although of considerable size on January 19, declined rapidly after a few days and by January 27 had shrunk to less than 200 millionths in area. In association with group (2) an extensive bright $H\alpha$ eruption occurred on January 27 between 10^h and 12^h. This eruption was recorded on hydrogen spectroheliograms taken by Mr. Evershed at his private observatory at Ewhurst, Surrey; at Greenwich it was cloudy at the time. The first spectroheliograms, taken at 10^h 36^m and 10^h 46^m U.T. respectively, show a patch of strong $H\alpha$ emission at a position 22° N. and 23° W. of the sun's central meridian; at 10^h 55^m the eruption was still present, but at 12^h 7^m when the last spectroheliogram was taken the eruption had almost faded from view. The beginning of the eruption, normally very sudden, may therefore be placed at some minutes earlier than 10^h 36^m, and the ending, usually much less definite, at about 12^h 10^m.

IT is interesting to record that a radio fading on short-wave wireless transmission was reported to have occurred at the same time on January 27 from 10^h 25^m to 11^h 50^m. A passing comment may be made on the fact that bright solar eruptions, associated with fadings of short-wave radio transmission over daylight channels, occurred at 27-day intervals on December 30 and December 3 last (see NATURE, Dec. 12, p. 1017 and Jan. 9, p. 61). Furthermore, this apparent 27-day sequence is carried back still further by the recorded radio fadings on November 6 and October 9. The requisite international solar data are not yet published to see whether bright solar eruptions were observed at the time of the radio fadings on the last two dates. At the time of going to press, it is reported from the Royal Observatory, Greenwich, that the third group of the above list has increased greatly in size, and on January 31 it was about 2500 millionths of the sun's hemisphere in area. The group is likely to be the largest recorded since 1928.

Recent Crystallography

IN his Friday evening discourse at the Royal Institution on January 29, Sir William Bragg discussed recent work in crystallography. When X-rays were first applied to the determination of crystal structure, the forms examined were naturally those of simple design. As the technique improved, and as insight was gained into the modes of construction of which Nature made the most use, it became possible to attack more difficult examples with success. Quite recently, the X-ray methods have been able to give material assistance in the examination of the complicated bodies which play the leading part in the living organism, such as the proteins. X-rays have the special power of discerning regularities in the arrangement of the atoms and molecules of which substances are built. Until they were applied to this purpose, no one had suspected how usual and fundamental such regularities were. Nature's structures are generally based on the repetition of some unit of pattern. Even a very small crystal is formed of the orderly repetition of some atomic design repeated billions of times: and the minute but ubiquitous proteins of all living organisms possess this ordered arrangement though they are far too small to be seen in the microscope.

THE proteins all have the same basic composition. This again is an instance of the remarkable limitation to a few fundamental and elemental designs which is characteristic of the natural world. Every protein is composed, in the first instance, of a long chain in which two atoms of carbon and one atom of nitrogen form a pattern of three links, repeated throughout the whole length. Pendants of several varieties are attached to this chain, and one protein differs from another in the nature and variety of its pendants. The work of Astbury and others has shown the details of the construction of the proteins which make up the fibre of wool and hair and horn. It appears that in some substances, such as the uncooked white of an egg, the protein chain is coiled up into the form of a ball. Quite recently, Stanley, of the Rockefeller Institute, has been successful in isolating what is almost certainly the virus of the tobacco plant disease, and showing that it is a protein. This is most remarkable since the virus, by some means or other, is capable of multiplying itself. Bernal and his collaborators have shown that it is crystalline, and have used the X-rays to measure the regularities of its construction. It is of enormous size, relatively to the usual molecular dimensions, having a molecular weight of about twenty millions. It is needle-like in form. It has the optical properties of a crystal. This remarkable combination of properties is probably to be found in other forms of disease-producing virus, and the new discovery may well prove to be of the greatest importance.

Germany and the Nobel Prizes

DURING Herr Hitler's speech to the Reichstag in the Kroll Opera House, Berlin, on January 30, it was announced that he had issued a decree forbidding Germans to accept any Nobel Prize in future. This decree has been issued to avoid repetition of "shameful events of the past", which presumably refers to the award of the Nobel Peace Prize last year to Herr von Ossietzky, the German pacifist. The decree has been received with resentment in Sweden; but the Swedish Nobel Committee looks upon it as Germany's loss, for, since 1901 (when the first prize was awarded), nearly one quarter of all the Nobel prizes have been awarded to German citizens, and during the past ten years twelve out of the forty-one

(*Continued on p.* 241.)

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THE ELECTRON: ITS INTELLECTUAL AND SOCIAL SIGNIFICANCE*

By Dr. Karl T. Compton,
President of the Massachusetts Institute of Technology

WITHIN the past five years, centenaries, bicentenaries and tercentenaries have been much in vogue. Every town or institution or event which has claim to distinction has sought the excuse of the calendar to remind the world of its claims to greatness. Thus we have recently celebrated the centenary of Faraday's discovery of the principles of electromagnetism and the bicentenary of Watt's invention of the steam engine—discoveries which have introduced the eras of electricity and of mechanical power. The city of Chicago has sought to tell us that the progress of mankind really began with the founding of that community, and has led us to spend millions of dollars to gain the impression that there is really some causal relationship between Chicago and world progress. In my part of the country, the city of Boston and its suburbs staged a succession of tercentenary celebrations, as proud of their past as Chicago is of its present. Greatest of all was last summer's tercentenary celebration of Harvard University, signalizing the firm basis of intellectual freedom and leadership which is the prime requisite for a free people in a democracy.

* Address of the retiring president of the American Association for the Advancement of Science, delivered at Atlantic City on December 28, 1936.

Encouraged by the success of the Chicago Century of Progress and the Harvard Tercentenary, I venture to feature my address as signalizing an anniversary of the discovery of the electron. To be sure, it is only one generation old, and a generation is a sufficiently vague unit of time for my purposes. Yet, in spite of its youth, it bids fair to rival Chicago in its contributions to economic progress, and Harvard University in its contributions to the understanding of this world in which we live. So I venture to assert that no institution or community which has used one of these milestones to take stock of its achievements and plot its future course has stronger claims to intellectual significance and practical utility than I will claim for the electron.

The history of science abounds with instances when a new concept or discovery has led to tremendous advances into vast new fields of knowledge and art the very existence of which had hitherto been unsuspected. The discoveries of Galileo, Faraday and Pasteur are such instances. But, to my notion, no such instance has been so dramatic as the discovery of the electron, the tiniest thing in the universe, which within one generation has transformed a stagnant science of physics, a descriptive science of chemistry and a sterile science of astronomy into dynamically developing sciences fraught with intellectual adventure, interrelating interpretations and practical values.

I take particular pleasure in mentioning these practical values, for even the most unimaginative and short-sighted, hard-headed, 'practical' business man is forced to admit the justification for the pure research—of no preconceived practical use whatsoever in the minds of those who led in its prosecution, and of all degrees of success and significance—which has been directed at the electron. For out of this research have come the following things which all can understand and appreciate : a growing business in manufacture of electronic devices which now amounts to fifty million dollars a year in America alone ; a total business of some hundreds of millions of dollars a year which is made possible by these electronic devices ; innumerable aids to health, safety and convenience ; and an immense advance in our knowledge of the universe in which we live.

The Background

In science, as in human affairs, great events do not occur without a background of development. The electron had an ancestry which can be traced back through the centuries. Its immediate progenitors were the electromagnetic theory of light, spectroscopy and the leakage of electricity through gases. First cousins were X-rays and radioactivity and quantum theory, for, out of a background of long investigation of bewildering and apparently unrelated phenomena, there burst upon the scientific world the X-ray in 1895, radioactivity in 1896 and the electron in 1897—all while investigators in the older fields of heat radiation and thermodynamics were finding those bothersome inconsistencies in these hitherto respectable subjects which led to that unexpected extension of Newtonian mechanics now called quantum mechanics. The concept of the electron, behaving according to the laws of quantum mechanics, is now the basis of most of our interpretation of all that falls under the good old name of natural philosophy.

That only the pioneers of the scientific world were prepared for these discoveries, however, is witnessed by the fact that a standard text-book of chemistry widely used in my student days in 1904 stated that, "Atoms are the indivisible constituents of molecules", and so late as 1911 a prominent physicist warned his colleagues not to be too hasty in accepting these new-fangled ideas.

The existence of electrons had been foreshadowed for a century by the facts of electrolysis, which led Davy and Berzelius to conclude that chemical forces were electrical in nature, and Faraday to conclude that electric charges exist only in multiples of some fundamental unit. For chemical acids and salts, dissolved in water, tend to split up into ions, that is, atoms or groups of atoms which move in an electric field in such directions as to indicate that they carry either positive or negative electric charges. Furthermore, it is found that the amounts of these ions which carry equal amounts of electricity are exactly proportional to the chemical combining weights of the ions. Faraday saw that this fact would be simply explained by assuming that every ion carries a charge proportional to its chemical valency, that is, the valency times a fundamental unit charge. But Faraday could not, from these facts, deduce the size of this unit of charge ; he could only state the ratio of this charge to the mass of the chemical substance with which the charge was associated. Hydrogen, being the lightest of all ions, had of all known substances therefore the largest value of this ratio of charge to mass.

The first real evidence of particles of larger ratio of charge to mass than hydrogen ions came from the field of optics. Ever since Maxwell's equations of electromagnetism had predicted the existence of electromagnetic waves with the velocity of light, and Hertz, seventeen years later, had discovered them experimentally, physicists had felt sure that light must be caused by some sort of oscillations of electricity within atoms. But only the vaguest and most unsatisfactory speculations, such as whirling vortices or pulsating spheres of electricity, had been suggested.

In 1896, however, Zeeman tried the experiment of examining the spectrum of a light source placed in a strong magnetic field, and discovered that the spectrum lines thus became split into components of slightly differing wave-length, and that these components of the light showed characteristic types of polarization depending on the direction in which the light emerged from the magnetic field. Almost at once, in January 1897, Lorentz showed that this experiment proved that light is caused by the oscillation of electric charges, the motions of which are affected by the magnetic field in the manner required to explain Zeeman's experiments. This much was not unexpected, but what was startling was Lorentz's proof that the Zeeman effect could only have been produced by electrified particles whose ratio of charge to mass is nearly two thousand times larger than that of a hydrogen ion, and whose mass is therefore presumably nearly two thousand times lighter than hydrogen.

Almost at once this conclusion was confirmed in a more dramatic and understandable way by J. J. Thomson, the then youthful director of the Cavendish Laboratory. But let me first pick up this thread of the story a little farther back.

Discovery of the Electron

All through the eighteen-eighties and early eighteen-nineties a series of most striking and unexpected discoveries followed from investigations of electric arcs, sparks and especially the glowing discharges of electricity at high voltages through glass tubes containing various gases at pressures far below atmospheric pressure. The striking colour effects, mysterious luminous streamers and entirely bizarre behaviour of these discharges made them the most popular, yet most elusive, subject of laboratory research of those days.

It was these phenomena which led Crookes to postulate the existence of a mysterious "fourth state of matter", different from the solid, liquid or gaseous states. (Of course, we now know that Crookes's fourth state is simply the ionized state of matter.) Once, while attempting to photograph the appearance of a discharge at very low gas pressure, Crookes was bothered by the fact that all the photographic plates in the room with his apparatus became fogged, as if light-struck in spite of their opaque wrapping. He avoided the trouble afterwards, however, by keeping his new supply of plates in another room until, one at a time, they were wanted for use. Thus he solved an experimental difficulty, and missed making a great discovery.

At about the same time Röntgen, in Germany, was trying the same experiment, and he too was troubled by the fogging of his photographic plates. But, as the story goes, his laboratory assistant directed his attention to the peculiar fact that these fogged plates, when developed, showed the image of a bunch of keys which had accidentally been lying on top of the box of plates while the electric discharge experiments were in operation. Röntgen immediately looked into this and discovered that the fogging was due to penetrating radiations produced in the discharge tube where the cathode rays struck the target or anode. Thus by accident were X-rays discovered—that type of accident not uncommon in science when an observant experimenter is at work.

While on the subject of accidents, I might digress to tell of another accident which did not happen, also in connexion with X-rays. For more than fifteen years after their discovery, disputes raged as to whether X-rays were radiations, like light but of very short wave-length, or electrically neutral particles of small mass and high speed. It was evident that they were not electrically charged, since their paths were unaffected by electric or magnetic fields. The leading advocate of the neutral particle theory was W. H. Bragg. In 1912, at Princeton, O. W. Richardson tried an experiment to see if X-rays could be refracted by a prism. A positive result would support the wave theory of X-rays. People had tried this with X-rays through glass prisms without success, but Richardson had an idea that an iron prism might be more effective. So he passed X-rays for hours and days through the tapering edge of a Gillette safety razor blade, but without finding any refraction. If he had happened to try the edge of a crystal instead of the edge of the razor blade, he would undoubtedly have discovered the peculiar diffraction of X-rays in passing through crystals, discovered a couple of years later by Laue, Friederich and Knipping and developed by father and son, W. H. and W. L. Bragg, which proved both the wave nature of X-rays and the atomic lattice structure of crystals. If Röntgen's discovery of X-rays was an accident, then I suppose Richardson's failure to discover diffraction of X-rays was a negative accident. I often wonder how many important negative accidents slip past us week by week!

But to get back on the subject of the electron: it was the cathode rays, which produce the X-rays, which finally turned out to be electrons travelling at high speeds. These cathode rays had been observed to shoot out in straight lines from the surfaces of cathodes in rarefied gases through which electric currents were forced by high voltage. Objects which they struck became luminous with fluorescent light, and objects in their paths cast shadows. But their true nature was disclosed when a magnet was placed near the discharge tube, for then their paths were curved in a direction showing that cathode rays were negatively charged. By measuring this curvature produced by a magnetic field of known strength, and making a pretty sure assumption that the kinetic energy of these rays was determined by the voltage applied to the tube, J. J. Thomson in 1897 first showed that cathode rays are negatively charged particles with a ratio of charge to mass nearly two thousand times that of hydrogen. He furthermore showed that these particles are of the same type, as regards ratio of charge to mass, from whatever gas or cathode material they are produced. He therefore announced these particles, which he called 'corpuscles', to be universal constituents of all substances. Thus was the electron discovered.

Mass and Charge of the Electron

Quick and fast came experiments of ingenious design to study the electrons more accurately. They were pulled this way and that by electric and magnetic fields. They were caught in miniature metal fly-traps, called Faraday cages, to measure their charge and kinetic energy. They were detected in their paths electrically, or by photographic plates or by fluorescence. Continually refined from that day to this, we now know that an electron has a ratio of charge to mass which is about 1,842 times the similar ratio for a hydrogen atomic ion.

It was also very desirable to know separately the charge and the mass of an electron, and not just the ratio between these quantities. So an even more interesting lot of experiments has been carried on to measure the electron's charge. They were begun in about 1900 by J. J. Thomson and his colleagues, Townsend, H. A. Wilson and C. T. R. Wilson. I think a brief résumé of attempts to measure the electron's charge will throw an interesting sidelight on the versatility of scientific attack on a difficult problem.

The first attempts were by Townsend, by measurements on the motion and electrification of fog produced when electrolytic gas was bubbled into a region of air which was slightly supersaturated with water vapour, but too many uncertainties were involved to make this work convincing. The first accepted results were by J. J. Thomson, who, after an earlier attempt, employed a technique of producing fog under controlled conditions, developed by his colleague, C. T. R. Wilson, whose method was refined further by his pupil, H. A. Wilson.

It had long been known that water droplets of fog do not form in air which is somewhat supersaturated with water vapour unless there are nuclei, like specks of dust, on which the moisture can condense. Later, Townsend found that fog will also condense on ions, and more readily on negative than on positive ions. C. T. R. Wilson designed an apparatus in which dust-free air could be supersaturated with moisture sufficiently to permit condensation of fog droplets on negative but not on positive ions, which were produced by some convenient ionizing agent. So a fog was formed, in which each droplet of water was condensed on a negative ion. Thomson employed this apparatus in the following manner.

Of course, this fog gradually settled downward under the pull of gravity—slowly because the drops were small compared with the viscous resistance of the air through which they fell. It was like the slow settling of dust on the furniture and floor of a room. But the theory of the rate at which spheres move when a force drives them through a viscous medium was already well known, due to Stokes's law. From this law, measurement of the rate of fall of the fog in centimetres per second as measured by a little telescope focused on the top edge of the fog, combined with knowledge of the force of gravity and the viscosity of air, enabled Thomson to calculate the size of the individual fog droplets. Dividing the total amount of water in the fog by the amount in one drop gave him the total number of fog droplets, and therefore the total number of negative ions. H. A. Wilson added the refinement of superposing an electric field on the gravitational field which pulled the drops through the air. Then, as the fog settled to the bottom of the apparatus, it deposited its electric charge, which, altogether, was large enough to be measured with an electrometer. So, dividing this total charge by the number of ions composing it gave, as the charge of one ion, $3{\cdot}4 \times 10^{-10}$ electrostatic units. This was the first real measurement of the charge of an electron, and was the value quoted in the tables of physical constants when I became a graduate student in 1910.

About that time Millikan, who has always had a flair for picking strategically important subjects to which to devote his investigative talents, undertook with his students a revaluation of the electronic charge. Sources of error in the fog method were well recognized : fog droplets were not all the same size, though measurements could only be made on those smallest ones which fell most slowly; also droplets did not remain of constant size, smaller ones tending to evaporate and larger ones to grow; also there were unavoidable convection currents in the air which modified the rate of fall of the fog; and some droplets might contain more than one ion.

Millikan cleverly avoided or minimized these difficulties by using only a single droplet of some relatively non-volatile liquid like oil or mercury. By ionizing the surrounding air in an electric field he could put various electric charges on the drop. Illuminating it by a powerful light and viewing it like a star through a measuring telescope, he could measure its rate of fall under gravity and its rate of rise when pulled upward against gravity by an electric field, and keep repeating these observations for hours. These measurements were so precise that, to keep pace with them, he had to measure the viscosity of air with hitherto unequalled accuracy. When all this was done, he had proved conclusively that all electric charges are integral multiples of a fundamental unit charge, the electron, the value of which he set as $4{\cdot}774 \times 10^{-10}$ electrostatic units—about 40 per cent larger than the earlier estimates and believed by Millikan to be correct within one part in a thousand.

Within the past half-dozen years, however, doubt has been thrown on the estimated accuracy of this value from quite a different direction, in work with X-rays. Originally, X-ray diffraction experiments in crystals proved the geometric arrangement of atoms in the crystals, but did not establish the scale of distances between atoms or the X-ray wave-length. These distances, once the arrangement of atoms was known, were calculated from absolute values of the weights of the atoms, which in turn were derived from electrochemical equivalents and the value of the electronic charge. Thus X-ray wave-lengths, masses of atoms and distances between atoms in crystals all had values dependent on knowledge of the charge of the electron.

Recently, however, A. H. Compton, Bearden and others have succeeded in making measurements of X-ray wave-lengths by diffracting X-rays from a grating ruled with 15,000–30,000 parallel fine lines to the inch, and operating near the angle of grazing incidence. These measurements involve only knowledge of the number of lines per inch on the grating, and the angles of incidence and diffraction of the X-rays—both depending only on measurements of length and capable of high precision. X-ray wave-lengths thus measured were a little different from the earlier accepted values, and this cast doubt on the accuracy of the electron charge value which had been used in the earlier X-ray estimates. The difference was not large, only about one part in two hundred, but it meant either that experiments had not been as accurate as believed or that there was some unrecognized complicating factor.

So Millikan's work has been repeated in various laboratories with refinements, such as the use of a remarkably non-volatile oil for the drop. But the chief error was found to lie in the measurements of the viscosity of air. During the past year Kelletrop, of Uppsala, has thus published a revised 'oil-drop' determination of electronic charge as $4{\cdot}800 \times 10^{-10}$ E.S.U., which is in excellent agreement with the 'X-ray' determinations. Bearden has just presented his own confirmation of this agreement before the American Physical Society.

It is an interesting coincidence that this best value of the charge of the electron is exactly the same as the figure given by Rutherford thirty years ago, though then determined with so much less precision that not much confidence was placed in it, except as to order of magnitude. It was then known that the alpha rays from radium are helium atoms which have lost two electrons and are therefore doubly positively charged. Rutherford caught a lot of these alpha rays in a metal trap, measuring their aggregate electric charge with an electroscope, and counting them by the scintillations which they produced on striking a fluorescent screen or otherwise. Dividing the total charge by the number gave him double the electronic charge, which he thus calculated to be $4{\cdot}8 \times 10^{-10}$ E.S.U. Already knowing the ratio of charge to mass with high precision, this value of the charge enables us to fix the electron's mass as $9{\cdot}051 \times 10^{-28}$ grams.

Electromagnetic Mass

When we speak of the mass of an electron, however, we enter a whole new field of ideas. Some years before the discovery of electrons, J. J. Thomson had pointed out that an electrified particle will possess inertia, that is, mass, simply in virtue of its charge alone, irrespective of whether or not it has any mass of the gravitational type which we have been accustomed to think of. This 'electromagnetic' mass comes about from the fact that any mechanical energy which is expended in accelerating an electric charge is transformed into the energy of the magnetic field surrounding the electrified particle in virtue of its motion. In fact, the kinetic energy of a moving electric charge is found to be simply the energy of its magnetic field and depends only on the square of the velocity of the charge, the amount of charge and the geometrical shape of the charge.

Making the simplest possible assumptions about the shape of an electron, such as a solid sphere or a hollow spherical shell of electricity, and assuming all its mass to be of electromagnetic origin, the diameter of an electron was calculated to be of the order of 10^{-13} cm. It must be emphasized, however, that this estimate of size is not, like the charge and mass, a definite measurement, but is simply an estimate based on assumptions, at least one of which is quite uncertain. For while we have both logic and experiment to back up the assumption that all the mass of the electron is of this electromagnetic origin, we must confess to utter ignorance regarding the shape of the electron. Indeed, some facts suggest that it may have different sizes and shapes in different environments, as in the free state or in an orbit of an atom or in the nucleus of an atom. So our estimate of 10^{-13} cm. for the size of an electron is, at best, very crude.

The idea of electromagnetic mass was strongly supported by the fact that measurements of the mass of very fast moving electrons, through measurements of the ratio of charge to mass of beta rays from radium or cathode rays in high-voltage discharge tubes, showed that their mass is not really a constant thing but increases with the speed of the electron. The value of electron mass given above applies, strictly speaking, only to an electron at rest. Practically, however, it is accurate enough for practical purposes for electron speeds below about one tenth the speed of light. At this speed the electron's mass is about half of one per cent larger than if it were at rest. At still higher speeds, the mass increases more and more rapidly, approaching infinite mass as the speed of light is approached.

These facts, experimentally determined, were shown by Abraham to be of the type expected if the entire mass of an electron is of electromagnetic origin, due entirely to its electric charge. It was this argument, which has since received confirmation from other directions, which was the basis of the theory that all mass, that is, all matter, is electrical. However, the simple electromagnetic concepts were not quite adequate to give an accurate quantitative interpretation of these experiments, and it required the additional introduction by Lorentz of the concepts of the special theory of relativity to bring about complete interpretation of the experiments.

The Electron and Quantum Theory

Just two things more do we know accurately about the properties of electrons, in addition to their charge and mass. We know that they are also tiny magnets of strength equal to the basic unit of magnetic moment generally called the Bohr magneton. Once the electron had been discovered, it became natural to seek in it also the explanation of magnetic phenomena, since it was only necessary to assume that the electricity of an electron is whirling about an axis, and the electron becomes endowed with the properties of a tiny magnet. Parsons, Webster and others examined the possibilities inherent in various assumed configurations, with interesting results. But it was only with the introduction of the quantum theory for the interpretation of atomic structure and spectra that the magnetic character of the electron has, within the last dozen years, been put on a well-established basis.

The other thing we know is perhaps the most unexpected of all the electron's properties—it behaves like a wave when it collides with other objects. Davisson and Germer discovered this in the Bell Laboratories, while examining the way in which a beam of electrons, incident on a solid surface, was scattered or reflected by it. They found, if the surface were crystalline, that the electrons were scattered just like diffracted X-rays, but that, unlike X-rays, the wave-length of an electron is not fixed but varies inversely as its speed. J. J. Thomson's son, G. P. Thomson, has made very illuminating studies of this phenomenon, which is the inverse of the Compton effect; together they have given physicists two mottoes: "Particles behave like waves and waves behave like particles" and "Here's to the electron: long may she wave". One of the triumphs of the new wave-mechanics (a brand of quantum mechanics) is that it offers a medium of explanation of these strange phenomena. But my subject of the electron is too long to let me attempt a digression on wave mechanics.

Significance of the Electron Concept

With this sketch of the electron itself before us, let us turn to some of the more important directions in which the electron has given us an interpretation of the physical universe generally. Immediately were explained the phenomena of electrolysis and of ionization generally, for ions were simply atoms or groups of atoms which had gained or lost one or more electrons. Primary chemical forces were explained as the electrostatic attraction between atomic groups which, respectively, contained an excess or a deficiency of electrons. (The more refined interpretation of chemical forces within the past half-dozen years, by Pauling and Slater, has been based upon the quantum theory of atomic structure.)

The three types of rays from radioactive substances were interpreted : alpha rays as helium atoms which had lost two electrons ; beta rays as electrons ; and gamma rays as X-ray-like radiations. In fact, Becquerel showed the magnetic deflection of beta rays in the same year, 1897, that Thomson showed the magnetic deflection of cathode rays and interpreted them as electrons.

For many years two unexplained phenomena had been studied in metals. When highly heated or when illuminated by ultra-violet light, metals had been shown to emit negative electricity. It was the work of but a year, after the discovery of the electron, for J. J. Thomson and his pupils to show that both these phenomena consist in the emission of electrons. But by what mechanisms are they thus emitted ? That was a question the study of which has led to most important theoretical and practical consequences.

Richardson, first as a pupil of Thomson and then as a professor at Princeton in the early nineteen hundreds, developed the theory of thermionic emission of electrons, according to which the electrons are evaporated from the surface of a metal at high temperatures by a process very analogous to evaporation of molecules. The electrons are assumed to have the same distribution of kinetic energies that molecules possess at the same temperature in accordance with the principles of kinetic theory. They escape from the surface, if they reach it, with enough energy to take them away in spite of the attraction tending to pull the electron back into the metal. This attraction is expressed in terms of the now famous 'work-function', a sort of latent heat of evaporation of electrons, which is the work that must be done to get an electron clear of the surface. With these simple assumptions, an equation was derived for the rate of emission of electricity as a function of temperature which has stood the test of perhaps as wide a range of experimentation as any other equation of physics, a range of values of more than a million-million fold in current without any detectable departure from the theory, if this is properly applied.

Richardson's measurements of the 'work-functions' of various metals showed that these values run closely parallel with one of the longest known but least understood properties of metals, namely, their contact potential properties. By contact difference of potential is meant the voltage difference between the surfaces of two metals when they are placed in contact. Richardson found that the difference between the 'work-function' of two metals was, within the limits of accuracy of the data, the same as their contact difference of potential. He therefore proposed the theory that the contact potential property of a metal is determined simply by the work necessary to remove an electron from its surface.

As a beginning graduate student under Richardson in 1910, I was given the job of undertaking a test of this theory through experiments on the other electron-emitting phenomenon, the photoelectric effect. Einstein a few years before had proposed his famous photoelectric equation, which was a contribution to physical theory certainly comparable in importance and thus far more useful in its applications than his more impressive and wider publicized general theory of relativity. According to it, an electron in a metal may receive from the incident light an amount of energy proportional to the frequency of the light—to be exact, an energy equal to Planck's constant h times the frequency ν. If it escapes from the metal, it must do an amount of work w to get away, so that its kinetic energy after escape from the metal would be the difference $h\nu - w$. Obviously, by measuring these kinetic energies of electrons liberated from various metals by light of various frequencies, it should be possible to find out if the 'work-functions' w of different metals are indeed related to their contact differences of potential in the manner predicted by Richardson's theory.

In two papers, by me in 1911 and jointly with Richardson in 1912, it was concluded first that the contact differences of potential are related to the 'work-functions' as Richardson had predicted, and secondly that Einstein's photoelectric equation,

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rather than a rival theory then under discussion, properly described the facts. Practically simultaneously with this second paper, there appeared the report of a similar verification of Einstein's equation by A. L. Hughes, then in England, though lacking the quantitative connexion with contact differences of potential.

This early work was not very accurate, partly because of lack of good vacuum technique for maintaining untarnished surfaces in a vacuum, partly through lack of constant sources of ultra-violet light and partly because the ultra-violet spectrographs used to isolate the various wave-lengths of light gave a certain spectral impurity of scattered light of other wave-lengths. These sources of error were recognized but not overcome when Millikan, in 1916, made a striking advance by using doubly purified light or otherwise correcting for the effects of impurity, and secured a verification of Einstein's equation which was far more accurate than the earlier work as regards the value of Planck's constant h. In fact, Millikan's work remains to this day as one of the best determinations of this important constant. In regard to the 'work-function', however, this work of Millikan's was not so successful, for, after having apparently discovered facts at variance with Richardson's interpretation of the equation and its relation to contact potentials, these differences were ultimately found to reside in faults of experimental procedure or interpretation, so that Richardson's interpretation of Einstein's equation still holds.

In both thermionic and photoelectric effects, theoretical refinements have been introduced by the recent quantum mechanics, and great advances made in experimental technique. However, it is fair to say that their interpretations on the electron theory have been among the major achievements of this theory.

Conduction of Metals

While we are on the subject of electricity in metals, what constitutes the phenomenon of easy flow of electricity that is the distinguishing feature of metals ? J. J. Thomson at once suggested that this must be due to the existence in metals of electrons free from their parent atoms, moving freely, except for collisions, whenever an electric field was applied in the metal. The theory thus worked out was attractive, but it encountered inconsistencies. There was not even any real evidence that electricity in metals was conducted by electrons.

Then along came Tolman with one of his brilliant ideas, skilfully followed by experiment. It had earlier been suggested that, whatever are the carriers of electric current in metals, it should be possible to centrifuge them toward the periphery of a disk if this were rotated very rapidly about its axis. To be more specific, if electrons are free to move in metals and if a wire connects the centre and the periphery of the rotating disk through lightly pressing brush contacts, electrons should be thrown out of the disk at its periphery and pass back into the centre of the disk through the wire. It would be rather analogous to a current of water driven by a centrifugal pump through a pipe circuit. But all attempts to detect such currents proved futile, because the currents produced by the friction of the contact against the periphery were far larger than the currents to be expected from the centrifuging of electrons.

But Tolman devised two methods of giving powerful accelerations to metal conductors in such manner that he was able to measure the feeble electric currents that were produced as the carriers of electricity in the metal were shaken back and forth, and his calculations showed that these currents were indeed of the size to be expected if the current is carried by electrons. This is our direct evidence that electrons carry the electric current in metals. The mechanism by which they do this is now beginning to be disclosed by Slater, on the basis of an application of quantum mechanics and spectroscopic ideas to metals, and again is an example of the refining power of the quantum theory to succeed where older classical theory was gropingly suggestive, but inadequate.

Structure of the Atom

Now that I come to the most basic of all the phenomena which the electron has been called upon to interpret, I almost lose courage, for the subject is too vast and complex for anything but encyclopædic treatment. I refer to the structure of atoms. Previous to the discovery of the electron, literally nothing was known of the internal structure or composition of atoms. With this discovery, however, it immediately became evident that all atoms contain electrons and an equivalent amount of positive electricity in some form. It was again J. J. Thomson's genius which began the investigation of the inner atom. This was only about twenty-five years ago.

Thomson reasoned that, if X-rays were made to fall on any substance, the electrons in the atoms of the substance would be forced to vibrate back and forth by the powerful alternating electric forces in the X-ray waves. But, in thus vibrating back and forth, these electrons would re-radiate secondary X-rays in all directions. He calculated just what fraction of the original X-ray energy ought to be thus re-radiated by each electron, and then set his pupils to measure just what this fraction was in specific cases. From the experimental results he was thus able to calculate the number of electrons which performed the re-radiation in each case. These results indicated that the number of such acting electrons in each atom was about half the value of the chemical atomic weight of the atom. Thus first were counted the electrons in an atom.

Rutherford and his pupils, aided by the mathematical analysis of Darwin, tackled the problem from a different point of view. They studied the distribution of deflection of alpha particles, shot out of radioactive materials, as these alpha particles traversed thin sheets of solid materials. They found that this distribution was quantitatively what would be expected if the deflections were produced by ordinary electrostatic forces, varying as the square of the distance, between the alpha particle and a very small object containing most of the mass in each atom. They were thus able to show that this small object is not more than one ten-thousandth of the diameter of the atom, that it contained substantially all the mass of the atom and that it carried a positive electric charge equal, in electronic units, to about half the chemical atomic weight of the atom.

Thus arose the concept that the atom is composed of a positive nucleus of small dimensions, surrounded by electrons to the number of about half the atomic weight.

This had scarcely become established when it was brilliantly refined and extended by Moseley, just before he went to his untimely death in the Great War in 1914. Moseley had made a most ingenious study of the spectra of X-rays of a large number of the chemical elements, using a modification of the X-ray spectroscopy technique developed by the Braggs. He found that the square roots of the frequencies of the characteristic X-ray lines were numerically very simply related to the number which gave the place of the element in the periodic table of the elements, so useful to chemists but so entirely without explanation. Thus this number acquired a definite physical significance and is now well known as the 'atomic number'.

For all the elements heavier than hydrogen, this atomic number is about half the atomic weight and, to make a long story short, this atomic number turns out to be exactly the number of electronic units of charge on an atomic nucleus, or the number of electrons in the atom outside the nucleus. At the same time, Moseley's work proved to be one of the greatest advances ever made in the basic interpretive side of chemistry.

Now that the number of electrons in each atom was known, the next step was to wonder how they were arranged, what held them in place and what they were doing in their spare time. Suggestions were not slow in coming. In fact, even before Moseley's work, two rival theories had appeared, one devised by chemist Lewis and extended by Langmuir to explain the directional symmetries of atoms as indicated by their molecular combining forms, and the other devised by physicist Bohr to account for spectra. Gradually the Bohr theory has been developed to include the symmetries of the Lewis-Langmuir theory, so that both may be said to be merged, with many major additions too numerous to mention.

It was Bohr's bold genius to cast off some of the fetters of classical mechanics, which had been fairly well proved inadequate to meet the situation, and to devise a new mechanics frankly to meet the simplest known facts of atomic structure and spectroscopy—the hydrogen atom and the atomic hydrogen spectrum. In doing so, he at one stroke brought into the same picture the quantum theory of radiation, the electronic structure of the atom and the facts of spectroscopy. He had his electron moving in a circular orbit around the nucleus under the regular laws of electrostatic attraction and centrifugal force. But he stipulated that only such orbits were possible in which the angular momentum of the electron was an integral multiple of Planck's constant h divided by 2π. He also stipulated that the electrons should not radiate energy while revolving in their orbits, but only when they jumped from one orbit to another. In this case the frequency of light radiated was equal to the change of energy of the electron between the two orbits, divided by Planck's constant h. With these assumptions, the spectra of hydrogen and of ionized helium were quantitatively explained in their main features, but not in their finer details.

Then came the Great War, and we heard little of atomic structure in the United States. But in Germany, Sommerfeld was extending Bohr's ideas in most interesting ways. He showed that, by considering elliptic as well as circular orbits, and taking account of the variation of the electron's mass with speed, the fine details as well as the main features in the spectra of hydrogen and ionized helium were accurately explained. He also showed how the theory could be extended to deal with atoms where there were many electrons moving in orbits. He showed that these additional concepts were in the right direction to explain the more complicated spectra both in the visible and in the X-ray regions.

Spectral Lines

When this new work first was known in America, it started the most feverish and earnest scientific activity that the country has ever known, which is still in progress with undiminished zeal and with increasing productive effectiveness. I well remember when the first copy of Sommerfeld's "Atombau und Spectrallinen" came to America in the possession of Prof. P. W. Bridgman. Until later copies arrived, he knew no peace and enjoyed no privacy, for he was besieged by friends wanting to read the book—which he would not allow to go out of his possession. I recall, too, the sudden popularity of the only two or three men in America who knew what a spectral series was. Heretofore, practically our only interest in spectra had been in the culinary variety of spectroscopy used by chemists in identifying chemical elements. No interpretive quality to speak of had hitherto been attached to the peculiar numerical regularities which had been discovered in the vibration frequencies of groups of spectrum lines.

I recall, too, the dismay with which we found only a handful of mathematical physicists versed in the analytical dynamics underlying the new atomic structure theories. In the summer of 1921, having been taught by one of these few mathematical physicists, I went to the University of Michigan to lecture on Sommerfeld's theory, and found there also F. A. Saunders, invited to impart his knowledge of spectrum series. In the winter of 1926, Born and Jordan having just announced a new development in quantum mechanics, I found more than twenty Americans in Göttingen at this fount of quantum wisdom. A year later they were at Zurich, with Schrödinger. A couple of years later, Heisenberg at Leipzig and then Dirac at Cambridge held the Elijah mantle of quantum theory. In America, contributions are coming rapidly, particularly in the fields of application to chemical interpretations, metals and other complex situations.

From all this has come the situation which permitted Dirac, a few years ago, to write: "The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known, and the difficulty is only that the exact application of these laws leads to equations much too complicated to be soluble". But if any ambitious young scientist be discouraged lest there be little left to do, let him consider the unexplored atomic nucleus, or the fact that every attempt to apply these laws, which look so satisfactory to us now, discloses new realms of knowledge still unexplored.

Time forbids mention of the most interesting work which was done to check and extend the theories of atomic structure, through direct measurement of the energy states of atoms and molecules by carefully controlled bombardment of these molecules by electrons. Begun by Franck and Hertz in Germany, much of this work was done in America by Foote and Mohler at the Bureau of Standards, by my students at Princeton and by Tate's group at Minnesota, all since 1920.

Before leaving the interpretive triumphs of the electron, however, I cannot refrain from jumping from the atom to the universe, to the interpretation of conditions on the stars. Spectra of stars had long been known, and these were interpreted as indicating that some stars consist principally of hydrogen, others of helium and others of many chemical elements like our sun. But in 1922, a young Indian physicist, Meghnad Saha, first applied atomic structure theory and knowledge of ionizing potentials to the sun and stars. He considered ionization in the hot vapours of the stars to be like a chemical dissociation produced by heat, in which the products of dissociation are electrons and the positive ionic residues of the atoms, and in which the heats of dissociation are given by the ionizing potentials of the atoms. In this way was developed a rational quantitative interpretation of stellar spectra which has thrown enormous light on the problem of conditions of temperature, pressure and condition of the chemical elements in stars. Russell in America and Milne in England have ably applied and extended this theory.

The Electron in Industry

Finally, I come to the last phase of my subject, the social significance of the electron. By this I mean, of course, its useful applications. The first of these was Edison's invention of a thermionic rectifier, based on his discovery that negative electricity would flow across a vacuum from a hot filament to an adjacent electrode, but would not flow in the opposite direction. This was some years before the electron was discovered as the responsible agent in this phenomenon. But within a few years after the discovery of the electron, Fleming had shown that this same device will operate to rectify radio wave impulses, and thus permit their detection with a sensitive direct-current instrument. From this was patented the Fleming valve.

Once the basic character of thermionic emission was understood, and spurred on by the opportunities opening up in the radio field, new inventions, improvements and applications of thermionic devices came rapidly. Of major importance was the three-electrode tube amplifier of De Forest. Industrial research laboratories in the communications and electric manufacturing business took the lead in developing techniques and in penetrating scientific exploration. Noteworthy were the vacuum techniques and the monomolecular layers of activating materials developed by Langmuir and the high-vacuum thermionic X-ray tube of Coolidge. In the Bell Laboratories, oxide-coated filament tubes of good performance were developed and applied particularly to use in long-distance telephony. Let me give just two illustrations of the marvellous powers of some of these instruments.

It has been calculated that the energy of a trans-Atlantic radio signal caught by the receiving station in Newfoundland comes in at about the rate required to lift a fly seven inches in a year!

What is the largest number that has any physical significance? This is impossible to answer, being largely a matter of definition. But one common answer to this is 10^{110}, or one followed by 110 ciphers. This is about the number of electrons (the smallest things known) which would be required to fill up the universe to the greatest distances discovered by astronomy, if the electrons could be imagined to be closely packed side by side to fill up this whole space. Yet this number, large as it is, is very small indeed compared with the aggregate factor by which the energy of a voice striking a telephone transmitter in San Francisco is amplified by electronic tubes in the process of a long-distance telephone conversation to London. This amplification factor is about 10^{256}, or unity followed by 256 ciphers. If the universe were multiplied in size by the number of times it is larger than an electron, it could still not hold as many electrons as the number of this telephone amplification factor!

Then, mostly within ten years or so, has come an active introduction of thermionic devices which are not highly evacuated, but operate with supplementary action of intense ionization of the gas in the tube. First of these were the low-voltage arc rectifiers, like the tungar. Most interesting and versatile are the thyratrons, which permit easy control of powerful currents and machinery, and give a new means of converting alternating into direct current, or vice versa. In this group also are some of the new types of lamps, of high efficiency or special colour.

Not so striking, but equally interesting, have been the useful applications of the photoelectric effect. First was the use of sensitive photoelectric cells to replace the eye or photographic plate in astronomical telescopes. Then came sunshine meters, devices to open doors or count people or sort merchandise automatically, or to register the speed and licence number of the unwary autoist. Most important thus far are the current-producing mechanisms in the sound-movie apparatus and in television equipment.

While, commercially, radio, sound movies and long-distance telephony are at present of greatest importance, of no less importance, especially to us as scientists, are the marvellous tools which have been put into our hands for further research in practically every field of science, from physics and chemistry to psychology and criminology.

So we see how, within one generation, the electron has been discovered and examined, with its aid our intellectual outlook upon the universe has expanded in content and simplified in basic concept, and in its use mankind has the most versatile tool ever utilized. The end of the story is far from told. Every fact or relationship of the electron appears fuzzy with uncertainties when closely examined, for it can truly be said that every discovery discloses a dozen new problems. The field of practical and commercial uses of electronic devices is certainly still largely in its early stages of exploration.

This story illustrates in vivid manner a number of characteristics of scientific work, some of which I shall simply enumerate : (1) progress comes by spurts of advance as some big new idea opens up new territory, alternating with periods of consolidation ; (2) progress comes not by revolution or discarding of past knowledge and experience, but is built upon past experience and is its natural extension once the vision from new vantage points is secured ; (3) there is nothing so practical in its values as accurate knowledge, and the pursuit of such knowledge has been most successful when not fettered with the initial demand that it be directed toward practical ends.

I would not give the impression that it is only the electron which has given new life to modern physical science. A story of similar interest could be built around the new concepts of radiation and atomic energy as expressed in the quantum theory, or about the electron's big brother, the proton, or his rather nondescript cousin, the neutron. In the atomic nucleus is a field of further exploration of enormous promise, now only beginning to be opened up by use of radioactive materials, cyclatrons and high-voltage generators.

Although these things have happened very recently, no one has better described the process and intellectual value of this type of scientific research than did Aristotle in the quotation which is inscribed in Greek on the façade of the National Academy of Sciences building in Washington : "The search for truth is in one way hard and in another easy, for it is evident that no one can master it fully nor miss it wholly. But each adds a little to our knowledge of Nature, and from all the facts assembled there arises a certain grandeur."

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recipients of Nobel prizes for physics, chemistry and medicine (more than one quarter) have passed to Germans. Herr Hitler has decreed the creation of three German National Prizes of 100,000 marks (£8,300) each, to be awarded annually to Germans distinguished in art and science.

Gold Medal of the International Faculty of Sciences

AT the dinner following the annual conference of the International Faculty of Sciences applied to Human Progress, held in London on January 30, the Faculty's Gold Medal was presented to Mr. John Logie Baird, inventor of the Televisor, and managing director of Baird Television, Ltd. The chairman, Dr. Joseph S. Bridges, said the presentation was made in recognition of Mr. Baird's outstanding contributions to the science of television. In acknowledging the presentation, Mr. Baird indicated the progress that had been made since he first, in 1925, secured a television image with distinct definition. While the high cost of the apparatus at present is a drawback to its wide use among amateurs, he looked forward to a substantial reduction in the near future. Great Britain, he said, definitely leads in the science of television and is the only country in the world which has a television service. Among other speakers, Dr. L. E. C. Hughes commented on the necessity of scientific workers in all branches co-operating more closely to ensure that the achievements are properly applied to the requirements of human progress, and indicated the value of the International Faculty of Sciences in bringing into close touch such workers in all the countries of the world. Prof. B. W. Holman, replying on behalf of "The World's Scientific Workers", stressed the necessity for the social sciences being developed to keep pace with other sciences, so that the achievements of the research workers could be applied in accordance with the objectives of the Faculty, namely, human progress.

Aboriginal Tribes of the Malay Peninsula

WHILE of the aboriginal tribes of the Malay Peninsula the Sakai, the Semang and the Jakun, though by no means well known, have been the subject of careful investigation by a number of observers, the Temiar, a hill people of Perak, are virtually untouched in an anthropological sense. Yet they number nearly one half of the aboriginal population of 25,000. They have, however, been made the subject of a considerable study by Mr. H. D. Noone of the Perak State Museum, who has given some years to the investigation of their culture, their ethnic affinities, and their language, which is said to belong to the Austro-Asiatic group, and to show Indo-Chinese affinities. A preliminary outline of Mr. Noone's results in *The Observer* of January 24 is cabled from Singapore, where a number of the tribe are staying at present for the purpose of a record of their speech. It is there stated that Mr. Noone finds that the Temiar show traces of negritic influence and also an Australoid type, akin to the Vedda, but that, essentially a hill tribe, they link up with the hill stocks of Sumatra and other parts of south-east Asia. They are lighter skinned than the Sakai and belong to a higher order of intelligence and culture. They build communal long-houses instead of the rude shelters of the Sakai, use the bow, and hunt with the blow-pipe. Their religion is animistic. For driving out the spirits of disease, they make use of the religious dance, in which the medicine man is an important figure. These dances are performed in the event of an epidemic, the dancers becoming 'possessed' by a tiger spirit. Eventually they fall into a state of trance, which sometimes ends in complete rigidity.

Tracks for Cyclists

THE recent Ministry of Transport accident inquiry proves that, notwithstanding the increase in the number of motor-cars, the casualties among motorists are decreasing. On the other hand, casualties to cyclists are increasing at an even greater rate than we might expect from the growth of the cycling habit. According to a paper read at the National Safety Congress, fatal accidents to pedal cyclists during the seven years 1928–34 had increased no less than 122 per cent. In *Roads and Road Construction* for January 1, it is suggested that the best way to check increase of these accidents would be to copy some of our Continental neighbours and increase largely the number of special cycle tracks available. In Germany there are already about 1,100 miles of track, about two thirds of which is State maintained. According to a recent statement, the decrease which has occurred in recent years in cycling fatalities in Germany can be attributed directly to the making of these tracks. The German authorities are aiming at the provision of no less than 24,000 miles of track. The opposition that cyclists' touring clubs make to special tracks seems to arise from a fear lest these tracks be made not wide enough, so that they will have to travel at the most two abreast, instead of as at present three or four or even more abreast. In the interest of the general safety, it is probable that the privilege of riding three or more abreast will soon be curtailed by law. In many places cycle tracks, like public footpaths, could be built without fences, and probably a large mileage of existing 'green roads' could be utilized. If a number of special tracks were constructed every year, the annual cost need not be large. They would add safety, health and enjoyment to the weekly tours of many cyclists who at present have to pass through main roads crowded by rapidly moving vehicles and sometimes in an atmosphere full of noxious vapours.

Road Lighting in the United States

IN *World Power* of November some interesting statistics are given, relating to road accidents, which illustrate the responsibility of bad or non-existent lighting for road deaths and injuries. On the Mount Vernon Highway, near Washington, there were 2·87 accidents per million vehicles per mile, between July 1 and December 1, 1932. When lighting was suspended during the depression, the number of accidents increased to 7·02 over the same period per million vehicles per mile—an increase of 250 per cent.

In New Jersey at present, the night-time accident rates on three unlighted main roads carrying dense traffic are 270 per cent more than the day-time rates. Another striking figure is that more than half the 36,400 people killed by motor-cars in 1935 were injured during the hours of darkness, although the traffic volume was certainly not more than one third that during the day-time. It is concluded that it is not surprising that American engineers are alarmed when they see that New York State, for example, makes an annual expenditure of about twenty-two million dollars in getting rid of railway, street and highway crossings, and yet does little towards the illumination of roads at night. The total number of preventable accidents in 1934 due to railway crossings was 151.

Merseyside Fauna and Flora

THE Liverpool Naturalists' Field Club has recently issued volumes of *Proceedings* covering its activities for 1934 and 1935. This brings its number of annual *Proceedings* since its inception in 1860 to seventy-five, a noteworthy accomplishment, for they provide a valuable reference on the changing fauna and flora of the industrial north-west of England. The two latest volumes consist largely of the Ornithological Section report by Eric Hardy, who has built up within the Society the largest organized bird study group in the area. This includes bird-census counts over special areas, organized surveys of bird-calls at dawn and dusk, and statistics of migration and bird-ringing, nesting and rookery counts, etc. The Ornithological Section, states the Committee Report, is now organized independently of, but connected with, the general Field Club. The *Proceedings* also include Mr. W. A. Makinson's presidential addresses for the two years: "The Joys of a Nature Lover" and "Trees and their Service to Man". Reference is made to the discovery, in the Field Club library, of proof that the Society's first president and founder, the Rev. H. H. Higgins, visited the convent at Sinai and examined the famous "Codex Sinaiticus" previous to the examination by the collector Tischendorf. Having traced the journals of this Sinai visit, it is hoped to publish them.

The Scripps Institution of Oceanography

THE August issue of the *Collecting Net* (**11**, No. 5) contains an article entitled "Biological Research at the Scripps Institution of Oceanography" by Dr. Claude E. ZoBell. It is announced that Dr. T. Wayland Vaughan is retiring from the University of California, his successor being Dr. Harald U. Sverdrup. During Dr. Vaughan's administration, the Scripps Institute of Oceanography has expanded enormously, and since his appointment as director in 1924 he has gradually developed an extensive research programme in biological oceanography with workers in all subjects connected with it. Among the many great improvements an important one is the growth of the library, which now contains more than 14,600 volumes, 1,100 charts and 30,000 pamphlets. Dr. Vaughan has contributed to the Institution his own personal collection of 1,800 volumes and 6,000 reprints of relevant literature besides numerous periodicals.

Physics Research at Osaka University

VOL. 3 of the "Collected Papers in Physics" from Osaka University consists of thirteen copies of papers which have appeared in the Report of Radio Research in Japan, the *Proceedings of the Physico-Mathematical Society of Japan*, the *Japanese Journal of Physics* and the *Proceedings of the Institute of Radio Engineers of the United States*, between June 1935 and March 1936. They cover subjects such as atomic bombardment, short-wave production, modulation of oscillators, polar molecules, electron diffraction, neutrons and protons and dynatrons. The volume extends to about 125 pages, and is produced by wiring together the separate copies of the papers, with a title page and table of contents, the size of the page being 19 cm. by 26 cm. The original covers of the papers are retained. This inexpensive method of issuing collected papers from periodicals with pages of the same size seems worthy of extension.

Misunderstanding and Misprint

A CORRESPONDENT has sent us a copy of a programme for 1936–37 of a science society of a university, which contains two amusing misprints. The title of a paper to be contributed by a member of the zoological department of the university was sent in as "Life History of the Ling Cod". The secretary appears not to have recognized "ling" as a food fish of the cod family, so he altered the word to "living". The printers put the finishing touch upon the title by changing the last word also, so that the title appears as "Life History of the Living God", which must surely represent the most ambitious subject of a paper by a zoologist ever announced.

The Influenza Epidemic

THE Ministry of Health reports that during the week ending January 16 the number of deaths ascribed to influenza in the 122 great towns of England and Wales was 1,100, as compared with 768 in the previous week. The number of notifications of pneumonia in England and Wales was 2,823 as against 2,338 in the previous week. A considerable increase of influenzal cases has occurred in most of the naval and military commands; but the epidemic appears to be declining in certain parts of the south. The age distribution of deaths is somewhat reassuring, as it is not the type usually met with in severe epidemics. According to Science Service bulletins, a wave of influenza is passing over the United States.

Parkes Memorial Prize

MAJOR E. F. W. MACKENZIE, R.A.M.C., has been awarded the Parkes Memorial Prize for 1936 for his investigations into the ammonia-chlorine process of water purification in the field, coupled with research carried out by him in connexion with food supplies in India. The Parkes Memorial Prize is awarded annually to the officer who is considered by the committee to have done most to promote the advancement of naval or military hygiene by professional work of outstanding merit, and is open to medical officers of the Royal Navy, the Army and the Indian Army, with the exception of the professors and assistant professors of the Royal Navy Medical College at Greenwich and the Royal Army Medical College during their term of office.

Studies in Ancient Indian History and Geography

REGULATIONS have now been framed for the work of the Trust founded by the generosity of Dr. Bimila Churn Law, of Calcutta. The funds of the Trust will be used to facilitate the publication of original contributions to the literature on Buddhism, Jainism and the ancient history and geography of India, down to the end of the thirteenth century A.D. The Trust will be administered by the Royal Asiatic Society. Applications for assistance under the terms of the Trust for the period January 1, 1937–December 31, 1938, should be addressed to the Secretary of the Society, 74 Grosvenor Street, S.W.1.

Science and Society

THE Association of Scientific Workers has organized a series of five public lectures under the general title "Science and Society", to be given at University College, London, on successive Wednesdays, beginning February 17. The lectures cover a wide range of topics, and the whole series should prove of unusual interest to scientific workers. Prof. J. B. S. Haldane will talk on "Facts and Theories concerning Human Race Differences" on February 17, and the chairman on this occasion will be Sir F. Gowland Hopkins. On the following Wednesdays, the lecturers will be A. L. Bacharach on "Nutrition and Society", Prof. H. Levy on "The Socialization of Mathematics", Prof. P. M. S. Blackett, on "Physics" and Prof. Lancelot Hogben on "The Social Background of Science". This is the first of an annual series of lectures on the general implications of science which the Association hopes to arrange. Further information and tickets (1s. for each lecture, 4s. for course of five) can be obtained from the Assistant Secretary, Association of Scientific Workers, Kelvin House, 28 Hogarth Road, S.W.5.

Checking the Michelson-Morley Experiment

THE following cablegram has been received from Prof. W. B. Cartmel, of the University of Montreal: " 'A Simple Means of Checking the Michelson-Morley Experiment'. In a letter under the above title which appeared in NATURE of January 16, I reported experiments in which I found a large fringe-shift with a small interferometer having one arm inclined at an angle of 45° and the other arm level. Unfortunately, on continuing my experiments with improved apparatus, this fringe-shift disappeared altogether, so that we get the same result with one arm inclined and one arm level as we do with both arms level, the effect previously reported being apparently spurious."

Announcements

H.R.H. THE DUKE OF GLOUCESTER has accepted the invitation to become president of the British Empire Cancer Campaign. His Majesty the King, when Duke of York, was president of the Campaign from 1924 until his accession to the throne.

THE Council of the Physical Society has awarded the fourteenth Duddell Medal to Prof. W. G. Cady, of the Wesleyan University, Middletown, Connecticut, U.S.A.

MR. COLIN BEVAN REES has been awarded the Foyle Prize at the University College of South Wales for his essay on "Can Science make a Positive Contribution to the Elimination of Armed Conflict ?"

DR. LOUIS VERVAECK, director of the service of criminal anthropology in Belgium, has been awarded the Cesare Lombroso prize for criminal anthropology.

MCGILL UNIVERSITY, Montreal, has recently received a gift of 17,000 dollars from the Rockefeller Foundation to cover the expenses of a three-year programme of research in genetics and experimental cytology.

APPLICATIONS for grants from the Ella Sachs Plotz Foundation for 1937–38 must be made before May 1. For the present, researches will be favoured that are directed towards the solution of problems in medicine and surgery or in branches of science bearing on medicine and surgery. Further information can be obtained from Dr. Joseph C. Aub, Collis P. Huntington Memorial Hospital, 695 Huntington Avenue, Boston, Massachusetts, U.S.A.

THE Trustees of the Lady Tata Memorial Fund invite applications for grants and scholarships for research in diseases of the blood, with special reference to leukæmia, in the academic year beginning on October 1, 1937. The grants and scholarships are open to workers of any nationality. Applications must be submitted before March 31, and the awards will be made by the Trustees in June. Further particulars and forms of application may be obtained from the Secretary of the Scientific Advisory Committee, 138 Bedford Court Mansions, London, W.C.1.

ATTENTION may be directed to catalogue No. 42 of Messrs. E. P. Goldschmidt and Co., 45 Old Bond Street, W.1, on navigation, geography, travels and shipbuilding. The catalogue, which is illustrated with several reproductions of old maps, contains many old and rare items including Amman's "Die grosse Allegorie auf den Handel", 1622; Belleforest's "Cosmographie Universelle", 1575; Honter's "Rudimenta cosmographica", 1542, of which very few copies are known; a hitherto unknown first map of Japan, 1586; and Kepler's "Tabulae Rudolphinae", 1627–30, containing his rare world map, which Nordenskjöld believed to be the earliest map showing any indication of the Australian coast line.

Letters to the Editor

The Editor does not hold himself responsible for opinions expressed by his correspondents. He cannot undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.*

NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 252.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Magnetic Effects associated with Bright Solar Eruptions and Radio Fade-Outs

THE association of certain disturbances of the earth's magnetic field with bright hydrogen eruptions in the neighbourhood of sunspots, first indicated by Prof. Young, led to the conclusion that the solar effect was propagated to the earth with the velocity of light. Fresh impetus has been given these investigations by the observation of extensive radio fade-outs reported by Dellinger[1], at whose request special spectroheliograms were made at the Mount Wilson Observatory, Carnegie Institution of Washington, to investigate possible correlations[2]. A notable fade-out, a marked magnetic and earth-current disturbance, and an unusually bright hydrogen eruption on the sun, all occurring simultaneously, were observed from $16^h\ 45^m$ to $17^h\ 03^m$, G.M.T., on April 8, 1936, at the Huancayo (Peru) Magnetic Observatory of the Department of Terrestrial Magnetism, Carnegie Institution of Washington[3] and elsewhere. Since then, two other pronounced similar occurrences, one on August 25 and another on November 6, have been reported from the Observatory[4,5], and many instances of a less conspicuous nature have occurred[6].

The characteristic features of these phenomena as revealed so far are a marked increase in intensity of the $H\alpha$ line in the region of a sunspot, cessation of radio reflections from the ionosphere, in particular for the higher frequencies, and in equatorial regions an increase in the horizontal component of the earth's magnetic field, and increases in the electric currents flowing in the earth's crust such as would be induced by the magnetic changes. All the effects, as above noted, begin quite sharply at apparently the same time and end coincidently after a time-interval of the order of 45 minutes. Conditions after the disturbances appear to be normal. The terrestrial effects apparently are confined to the daylight portions of the earth.

The disturbances of the earth's magnetism which accompany these solar outbursts are distinct from the perturbations associated with magnetic storms—the latter are evident at all parts of the earth, while the strong magnetic effects recorded at Huancayo during the outburst of April 8 could not be discerned at the Carnegie Institution's Watheroo Magnetic Observatory, Western Australia, 169° west of Huancayo. Furthermore, both immediately before and immediately after the three notable outbursts mentioned, the earth's field was comparatively free of perturbations, while the perturbations of magnetic storms usually persist for several days; it is not to be implied, however, that the phenomena cannot or do not occur while a magnetic storm is in progress.

The nature of the mechanism which produces the magnetic effects may be surmised from the meagre data already in hand. The disturbance of August 25, for example, may be attributed to a sheet of current in the ionosphere flowing eastward over Huancayo and northward over Cheltenham (U.S.A.) with densities of 60 and 30 amp. per km. width of the current-sheet at the two places, accompanied by corresponding oppositely directed currents inside the earth[4]. In direction and magnitude this current approximates that assumed to produce the ordinary diurnal variations of terrestrial magnetism. Thus the magnetic effects may be ascribed to an increase of ionization, produced by radiation of shorter wavelength than visible light, accompanying the increase of $H\alpha$ intensity, causing an increase in the currents then flowing in the region of the ionosphere affected. The diurnal-variation currents are believed to flow in the lower, short free-path region of the ionosphere.

This hypothesis is consistent with the obvious explanation of the radio fade-outs—that they are due to increased ionization in the short free-path region where frequent collision causes large absorption of the radiated energy. Further, the rapid return to normal conditions, practically coincident with the cessation of the visible solar radiation, also indicates that the effect occurs in the short free-path region where recombination is very high.

An intensive investigation of these phenomena, designed to test this hypothesis and incidentally to clarify concepts of the diurnal variation of terrestrial magnetism and processes of ionization and recombination in the ionosphere, is under way at the Department of Terrestrial Magnetism.

A. G. MCNISH.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D.C.
Dec. 24.

[1] *Phys. Rev.*, **48**, 705 (1935).
[2] Richardson, R. S., *Pub. Astr. Soc. Pacific*, **47**, 325 (1935); **48**, 122 (1936); *Terr. Mag.*, **41**, 197 (1936).
[3] Torreson, O. W., Scott, W. E., and Stanton, H. E., *Terr. Mag.*, **41**, 199 (1936);
[4] Fleming, J. A., *Terr. Mag.*, **41**, 404 (1936).
[5] Torreson, O. W., Scott, W. E., Davies, F. T., and Stanton, H. E., *Terr. Mag.*, **41**, 407 (1936).
[6] Dellinger, *J. H.*, *Phys. Rev.*, **50**, 1189 (1936).

Rainfall and Moon Phases in the Tropics

ON the low-lying east bank of the Demerara River, about eight miles from its mouth, is situate Diamond Plantation, the largest sugar factory in British Guiana, located approximately at 6° 42′ N. and 58° 10′ W. Preserved at Diamond is a valuable record of the daily rainfall for the past forty-six years. Through the courtesy of the Plantation authorities, I have been able to secure a copy of the register.

So many farmers and planters in the West Indies and British Guiana have faith in the new moon or the full moon bringing rain, that it seemed of value to determine, from the Diamond data, what factual foundation there is for the belief.

Popular belief does not definitely fix the fall of rain for the actual date of the new or full moon, but for some time near the date. Thus one frequently overhears such remarks as: "It will be new moon to-morrow and we should get some rain to-night or to-morrow", or "The moon is full to-night so we may get some rain to-night or to-morrow". It was therefore decided to compare the average rainfall for:

(*a*) The three-day period made up of the day before new moon, the new moon day and the day after new moon;

(*b*) The three-day period immediately preceding (*a*);

(*c*) The three-day period immediately following (*a*);

(*d*) The three-day period made up of the day before full moon, the full moon day and day following the full moon;

(*e*) The three-day period immediately preceding (*d*);

(*f*) The three-day period immediately following (*d*).

This was done for the year as a whole and for the dry seasons only, since it might be argued that it is only during the latter that farmers are worried about rain and trouble to note the supposed relationship between precipitation and moon phases. At Diamond the weekly rainfall averages less than two inches from the week ending January 21 to that ending April 29, and again from the week ending August 12 to that ending November 25. These periods were taken as constituting the dry seasons. During the rest of the year the rainfall averages more than two inches per week.

Comparison of Average Rainfall (1914–34) in Inches at New and Full Moon with Rainfall Prior and After, at Diamond, E.B., Demerara, British Guiana.

	New Moon			Full Moon		
	3 Days prior (*b*)	3 Days at (*a*)	3 Days after (*c*)	3 Days prior (*e*)	3 Days at (*d*)	3 Days after (*f*)
Year	0·81 ± 0·06	0·82 ± 0·07	0·78 ± 0·07	0·85 ± 0·08	0·74 ± 0·06	0·93 ± 0·09
Dry Season	0·50 ± 0·06	0·51 ± 0·07	0·51 ± 0·08	0·48 ± 0·07	0·50 ± 0·07	0·62 ± 0·10

The results obtained for 259 new and 261 full moons (1914–1934), for the whole year, and for 147 new and 146 full moons, for the dry seasons, are set out in the accompanying table.

The differences between the means are as follows:

	Whole Year	Dry Season
a and *b*	0·01 ± 0·092	0·01 ± 0·092
a „ *c*	0·04 ± 0·099	0·00 ± 0·106
d „ *e*	0·11 ± 0·100	0·02 ± 0·099
d „ *f*	0·19 ± 0·108	0·12 ± 0·122
a „ *d*	0·08 ± 0·092	0·01 ± 0·099

It will be seen that none of the differences is significant and that there is no support whatever for the belief that there is likely to be more rain at the new or full moon than during the days just before or just after these phases. It is of interest to note, too, that the average rainfalls for the new moon and full moon periods are very similar.

C. HOLMAN B. WILLIAMS.
Sugar Experiment Station,
Department of Agriculture,
British Guiana.
Dec. 11.

Another Double Star Process giving Very Fast Particles

IN a recent letter[1] I pointed out that in order to explain the energies found in cosmic radiation it is necessary to introduce only one hypothesis: that the components of the double stars are magnetic dipoles (as the earth and the sun). Then a rotating double star acts as a cyclotron. A more detailed calculation[2] shows that energies of 10^{10} or 10^{11} (perhaps 10^{12}) electron volts are attainable, but as the accelerating process is rather complicated it seems unlikely that it can be responsible for the total intensity of cosmic radiation. Therefore it may be of interest to point out that there are also other—and more simple—double star processes which are able to give high-energy particles.

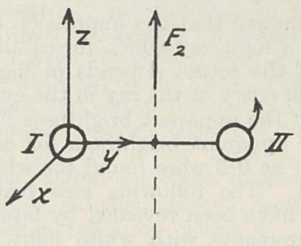


Fig. 1.

Let us assume that the two components I and II of a double star are parallel magnetic dipoles with the same moment (a). The star II rotates around I in the $x\,y$ plane with the constant angular velocity ω_0 and at the constant distance R_0 from I. If we follow the symmetry line parallel to the z-axis, the resulting magnetic field is always parallel to it. This means that charged particles can move freely in this direction. The field along this line is composed of the field H_1 from the component I supposed to be in rest, and the field H_2 from the component II which moves with the velocity $R_0\omega_0$. Now a moving magnetic field gives rise to an electric field. In our case the electric field component along the symmetry line is

$$F_2 = \frac{R_0\omega_0}{c} H_{2y},$$

where H_{2y} is the y-component of the magnetic field from II and c the velocity of light. The energy V (in electron volts) gained by a charged particle which has travelled from the $x\,y$-plane to infinity is

$$V = 300 \int_0^\infty F_2 dz,$$

and as $H_{2y} = \frac{3}{2} aR_0z \left[z^2 + \left(\frac{R_0}{2}\right)^2\right]^{-5/2}$, we find

$$V = 1{,}200 \frac{a\omega_0}{cR_0}.$$

If the period of the double star is 1 day, R_0 is 7×10^{11} cm. (ten times the radius of our sun) and

a is $2{\cdot}5 \times 10^{34}$ gauss cm.³ (five times the magnetic moment of the sun), we have

$$V = 10^{11} \text{ electron volts.}$$

If the orientation of the magnetic moments in relation to the rotation is the same as in our solar system, the accelerated particles have a positive charge.

HANNES ALFVÉN.

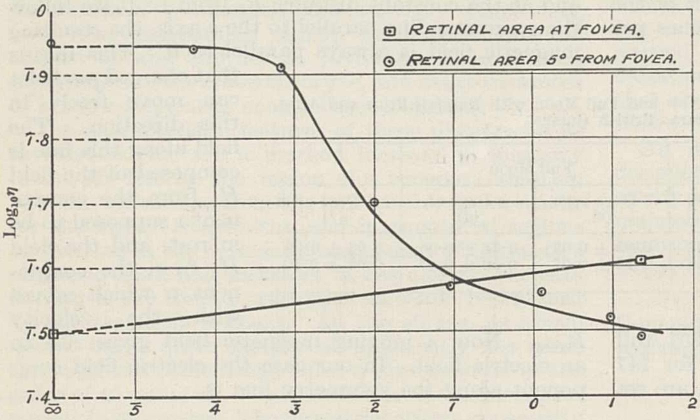
Physics Laboratory,
Uppsala.
Dec. 18.

[1] NATURE, **138**, 761 (1936).
[2] *Z. Phys.*, in the press.

Luminous Efficiency of Rays entering the Eye Pupil at Different Points

WE have shown[1] that the impression of brightness produced by a light ray which forms an image on a fixed area of the retina depends in high degree on the position of entry of the ray in the eye pupil. For the ratio η of the apparent brightness for peripheral entry to the apparent brightness for central entry, values as low as $0{\cdot}2$ were found for white light and foveal vision. The following new features of the phenomenon have been revealed by later work:

(1) Measurements with white light. When the ray is imaged at the fovea the variation of apparent brightness with point of entry is large whatever the brightness level to which the eye is adapted. When the ray is imaged at a point a few degrees to the side of the fovea (parafoveal vision) there is very little variation of apparent brightness with point of entry



Log₁₀ field brightness (c./ft.²)

Fig. 1.

for brightness levels below 0·001 c./sq. ft. As the brightness level is increased beyond this value, the effect sets in and is fully developed at a brightness level between 0·1 and 1 c./sq. ft. Fig. 1 shows the variation of $\log_{10}\eta$ with the logarithm of the brightness level, for foveal and parafoveal vision. In these experiments adaptation was secured by viewing a uniform brightness of the desired value. η was deduced from determinations of the smallest intensity of a ray, entering peripherally or centrally and imaged at the fovea or in the parafovea, which the subject could just perceive (liminal brightness increment).

(2) Measurements with monochromatic light. Foveal vision. The change of apparent brightness with point of entry shows a relatively small variation with wave-length, being greatest in the blue, least in the yellow. It was observed, however, that the monochromatic light changes colour as its point

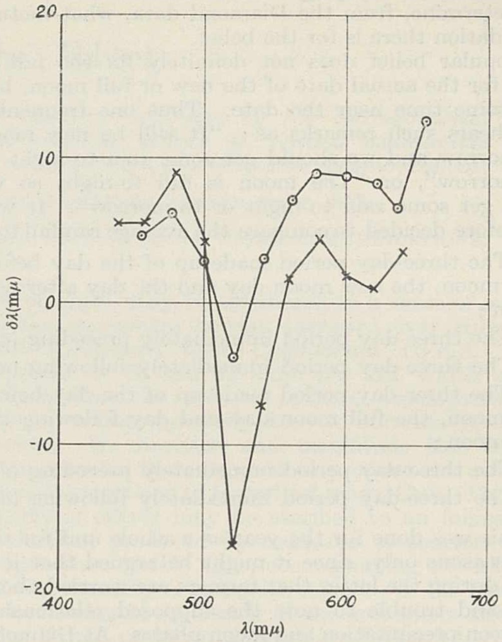


Fig. 2.

of entry is varied. The difference ($\delta\lambda$) in apparent hue for central and peripheral entry as a function of wave-length λ for two subjects is depicted in Fig. 2. In addition, in the green and blue-green, the peripheral ray appears more saturated.

Full details of these investigations are being published, but we may perhaps add here the following comments:

(*a*) The retinal origin of the effect is definitely confirmed.

(*b*) For the parafovea, the effect sets in at the brightness level commonly associated with the change-over from scotopic to photopic vision.

(*c*) The three types of receptors of the trichromatic theory must exhibit the effect in different degrees. This appears to be necessary to explain the observed colour change of physically homogeneous light.

W. S. STILES.
B. H. CRAWFORD.

National Physical Laboratory,
Teddington, Middlesex.
Dec. 24.

[1] Stiles and Crawford, *Proc. Roy. Soc.*, B, **112**, 428 (1933).

Forbidden Transition in the Spectrum of Interstellar Ionized Titanium

AN exploration of the ultra-violet spectra of a number of stars has recently been undertaken in collaboration with Dr. Walter S. Adams, using the aluminized mirror of the 100-inch telescope, a new grating of high efficiency ruled by R. W. Wood on an aluminized Pyrex disc, and an off-axis Schmidt camera[1] of 32 inches focal length which gives, in the second order, a scale of 10·2 A. per mm. Two sharp lines at λλ 3241·99 and 3383·78 the appearance of which suggests an interstellar origin have been photographed in the spectra of five stars of early type: ξ Persei (*Oe*5), λ Orionis (*Oe*5), χ Aurigae (*B*1), χ^2 Orionis (*B*2) and 55 Cygni (*B*2). The interstellar sodium pair ($3s^2S - 4p^2p^0$) at λλ 3302·38 and 3302·98 were used as standards in determining the wavelengths of these lines.

Since interstellar lines are likely to arise only from the lowest atomic level, a search was made in all spectra for terms having values close to 30,836·4 and 29,544·3 cm.$^{-1}$, corresponding to the observed wavelengths. The only terms having even approximately these values are in the spectrum[2] of Ti II: $z^4F^0{}_{3/2} =$ 30,836·52 and $z^4G^0{}_{5/2} =$ 29,544·37. Absorption from the ground state, $a^4F_{3/2}$, to these levels yields lines measured in the laboratory at λλ 3241·97 and 3383·76.

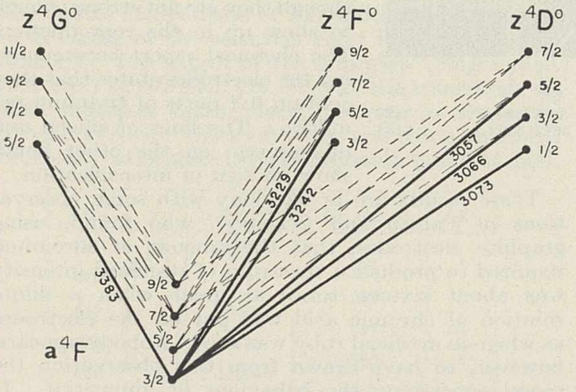


Fig. 1.

Fig. 1 shows that these lines are two of the twenty-eight possible transitions between the lowest term in the spectrum, a^4F, and the strong triad, z^4DFG^0. Four more lines from the ground level, a^4F, should occur at λλ 3229·18, 3072·97, 3036·36 and 3057·43. All these lines may be expected to be weaker than those at λλ 3241·97 and 3383·76. There was evidence for the line at λ 3229·18 ($a^4F_{3/2} - z^4F^0{}_{5/2}$) on an early plate. A longer exposure shows this line clearly and also the line at λ 3072·97 ($a^4F_{3/2} - z^4D^0{}_{1/2}$). The detection of these lines at the predicted positions confirms the identification of interstellar titanium. The lines at λλ 3066·36 and 3057·43 are satellites in the $a^4F - z^4D^0$ multiplet and could be detected only with difficulty.

The absence of all strong lines in these multiplets, excepting those arising from the very lowest sub-level, is of considerable theoretical interest. No absorption is observed even from the $a^4F_{5/2}$ level, which has an excitation potential of only 0·012 volt. In spite of the low density of radiation in interstellar space, all four sub-levels of the a^4F term would, at least after a number of years, become occupied in accordance with the Boltzmann relation, and absorption of all lines in each multiplet would necessarily be observed unless spontaneous downward transitions occur between sub-levels of the same term. The absence of absorption from any level but $a^4F_{3/2}$ appears to be definite evidence for the occurrence in interstellar space of the forbidden transitions, $a^4F_{7/2} - a^4F_{5/2}$ and $a^4F_{5/2} - a^4F_{3/2}$, which must emit lines at 76μ and 103μ. The $a^4F_{9/2}$ level cannot be filled unless there is already an accumulation in the $a^4F_{7/2}$ or the $a^4F_{5/2}$ level, and so in all probability no $a^4F_{9/2} - a^4F_{7/2}$ transition (59μ) occurs.

Atoms poised in one of the excited sub-states of the a^4F term in interstellar space can be interrupted and prevented from eventually making a spontaneous descent to the $a^4F_{3/2}$ state only by collisions with other atoms, electrons or with larger particles of matter, by absorption of stellar radiation, or by ionization through cosmic radiation. Collisions with other known atoms of sodium, calcium and titanium and with electrons are not likely to disturb a titanium atom more often than once in several weeks. It is harder to estimate the frequency of collisions with larger particles. Stellar radiation at λ3200 is diluted by a factor of about 10^{14} in interstellar space, according to Eddington's calculations, so that quantum absorptions must occur only at intervals of several centuries. Cosmic radiation may be expected to ionize each titanium atom once in something like 10^6 years, and can safely be neglected. The astrophysical evidence appears, therefore, to be consistent with a mean life-time of any duration up to several weeks for the excited sub-levels in question.

It is possible to calculate the probability of the magnetic dipole radiation which is principally involved in the transitions here considered, where the inner quantum number alone changes ($\Delta L = 0$, $\Delta S = 0$, $\Delta J = -1$). Dr. W. V. Houston has very kindly made this computation for me, and finds that the mean life-time of the $a^4F_{5/2}$ state in Ti II is approximately 28 seconds. It is, therefore, not remarkable that a titanium atom exposed to the conditions of interstellar space can nearly always return, after any type of excitation, to the lowest sub-level before revealing to us, in absorbing the next quantum of light, what state it occupies.

The theoretical life-time of about 28 seconds for the $a^4F_{5/2}$ state sets an upper limit to the mean density of interstellar matter, in aggregations of any specified size, if we assume a velocity distribution corresponding to Eddington's temperature of 10,000° K., and if we assume that collisions occurring more frequently than once in 28 seconds would maintain a distribution among the atomic sub-levels such that all lines in the multiplets would be observed. Various assumptions as to the sizes of the particles with which the titanium atoms collide lead to limiting densities ranging between 10^{-16} and 10^{-18} gm. cm.$^{-3}$. Since other evidence indicates that the density in space must be far less than this, it is clear that if an atom with a metastable state is to be useful as a density indicator it must have a life-time much longer than that of the $a^4F_{5/2}$ state of Ti II.

A consideration of the spectra and abundance of other elements indicates the possibility of detecting interstellar K I (7664), Ca I (4226), Sr II (4077), Sc II (3580), Fe I (3719) and Al I (3944). There is good evidence for the existence of interstellar K I and Ca I in recent spectra of distant *B* stars. An attempt is being made to determine, from the ratio Ca I : Ca II, the electron pressure in interstellar space.

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Dec. 14.

[1] *Phys. Rev.*, **46**, 326 (1934).
[2] Russell, *Astrophys. J.*, **66**, 1 (1927).

Latent Impurities in Electrodes used for Spectrographic Research

It has often been pointed out that for accurate results in quantitative spectrographic analysis, the standards of known composition, against whose spectra that of the specimen to be analysed is matched, should be made up on a base that simulates as closely as possible the composition of the specimen. This necessity arises from the fact that the intensity of the spectrum shown by a minor constituent of a mixture depends not only on the concentration of the element in question, but also on the nature of the major constituents. It has been shown, for example, that in the case of dilute solutions of lead salts, the lead lines are much stronger if the solution contains a considerable amount of zinc[1].

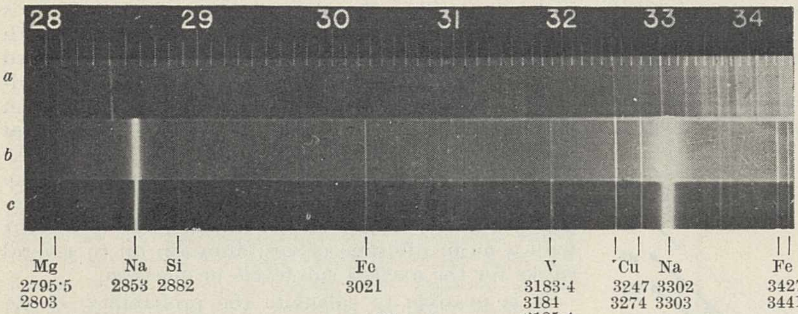

Fig. 1.

In the course of some analyses of animal tissues, which were begun in the Physics Department, Trinity College, Dublin, and are being continued in Cambridge, it has become obvious that this consideration applies not only to the constituents of the specimen, but also to impurities in the electrodes, and that failure to take account of it may render qualitative as well as quantitative results unreliable. The majority of workers in this field, and particularly those who were seeking only qualitative results, and did not, in consequence, have occasion to compare their specimens with standards of known composition, appear to have followed the practice recommended in all the practical handbooks of spectroscopy, of regarding a 'blank' spectrum of the electrodes alone, photographed in juxtaposition to the spectrum of the specimen, as being a sufficient safeguard against interpreting impurities in the electrodes as constituents of the specimen. But the fact is that in the case of carbon or graphite electrodes, impurities the strongest lines of which can only be faintly discerned in the 'blank' spectrum, may leap into prominence as soon as *any* mixture that approximately resembles a tissue ash is introduced into the arc.

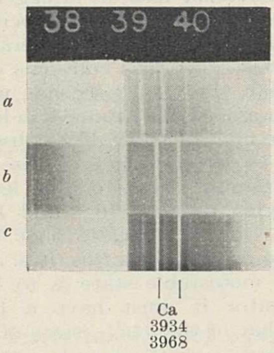

Fig. 2.

The accompanying illustrations (Figs. 1 and 2) show the effect of introducing pure sodium chloride into the arc struck between graphite electrodes, in which the principal impurities are vanadium, calcium and iron. (The manufacturers' claim that the sodium chloride is spectroscopically pure, except for a trace of silver, was verified by examining its spectrum in the silver arc.) It is clear that those lines of vanadium, calcium, iron and copper which are only with some difficulty visible in the spectrum given by the electrodes alone are greatly intensified by the presence of sodium atoms in the arc, while several lines of titanium, which could not be detected at all in the spectrum of the electrodes, also become visible on the plate, though they are not strong enough to show up in the reproduction. The chemical report accompanying the electrodes states that they contain 0·2 parts of titanium per million. The lines of silicon and magnesium, on the other hand, show no sign of intensification.

These results are in harmony with some observations of Papish and O'Leary[2], who found, using graphite electrodes, that the amount of chromium required to produce a spectrum of standard intensity was about sixteen times as great when a dilute solution of chromic acid was put on the electrodes as when an artificial ruby was used. Nobody appears, however, to have drawn from this observation the moral concerning the behaviour of impurities. It is hoped shortly to publish elsewhere, together with the results of the analyses themselves, a list of the elements that are likely, on account of this effect, to give misleading results in biological analyses. Meanwhile, it is clear that reports, by workers who have used carbon or graphite electrodes, on the distribution in living tissues of vanadium, titanium, copper, and possibly other elements, must be treated with reserve.

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Dec. 31.

[1] Nitchie, C. C., *Ind. and Eng. Chem.* (Anal. Ed.), **1**, 1 (1929).
[2] Papish, J., and O'Leary, W. J., *Ind. and Eng. Chem.*, **3**, 11 (1931).

Luminescence of Solutions of Terbium Salts

Very dilute aqueous solutions of terbium salts exhibit a bright luminescence when excited by the ultra-violet rays[1]. The maximal excitation is caused by the absorption of the wave-lengths coinciding with the broad absorption band of terbium, stretching from 290 mμ far towards the short wave-lengths[2]. The spectrum of this luminescence consists of 7 bands, each band being nearly 100 A. wide. The wave-lengths and frequencies of the middles of the bands are given in the accompanying table.

The second column gives a rough estimation of the intensities of the bands. It is seen that all the differences between the frequencies of the bands are fairly well expressed by the equation :

$$\Delta\nu_k = K\Delta\nu \qquad (1)$$

where $k = 1,2 \ldots$ and $\Delta\nu = 272$ cm.$^{-1}$. The maximal divergence is observed for the last difference $- \Delta\nu_6$. The deepest term of Tb+++ is a ^7F inverted term[3]; equation (1) should thus hold for the differences between the frequencies of its components also. It may be expected, therefore, that the luminescence bands would be emitted when transitions from a single upper state on all the components of the multiplet of the deepest term take place. This assumption is confirmed by the fairly good agreement which exists between the wave-lengths of one of the luminescence bands (possessing the shortest wave-length) and an absorption band observed in the solutions of terbium salts ($\lambda \sim 488$ mμ). Since the frequencies of the emission bands are considerably smaller than the frequency of the exciting light, it seems that besides the transitions on the deepest term, transitions between excited levels not accompanied by the emission in the visible and ultra-violet regions occur also. It is to be noted that the transitions on the components of the multiplet ^7F presume the breaking of the selection rule[4] for the quantum number j. The length of the afterglow (longer than 0·001 sec.) shows that the level at the transitions on which emission takes place, belongs to the well-screened $4f$ shell; the level at the transition on which absorption takes place belongs probably to the $5d$ shell.

λ mμ	I	ν (cm.$^{-1}$)	$\Delta\nu_k$ (cm.$^{-1}$)	K
681	1	14684		
			241	1
670	1	14925		
			507	2
648	1	15432		
			697	3
620	3	16129		
			965	4
585	6	17094		
			1255	5
545	10	18349		
			2058	6
490	10	20408		

The investigation of the luminescence spectrum of terbium solutions with a spectrograph with a higher dispersion has shown that the bands of the luminescence spectrum have a well-defined structure, depending on the nature of the anion, monovalent and bivalent acids having been investigated.

A similar luminescence is observed with the optical excitation of terbium oxide solutions in concentrated sulphuric acid. A detailed account will be published elsewhere.

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Dec. 22.

[1] Filippow, A., Larionow, J., and Seidel, A., *C.R. Acad. Sci. U.S.S.R.*, (10) **1**, 253 (1936).
[2] Prandtl, W., und Scheiner, K., *Z. anorg. und allg. Chem.*, **220**, 107 (1934).
[3] Vleck, J. H. van, "Theory of Electric and Magnetic Susceptibilities", p. 246 (Oxford, 1936).
[4] Ellis, S. B., *Phys. Rev.*, **49**, 876 (1936).

Enzymic Properties of Natural Papain

ACCORDING to the generally accepted view, papain is an enzyme which converts proteins (true ovalbumin excepted) into peptones, and is without effect on the latter. Hydrolytic power towards peptones and true ovalbumin is only acquired after treatment with certain reagents ('activators'), especially hydrogen cyanide[1].

We found that freshly tapped latex (milk juice) obtained from fruits of *Carica papaya* at different stages of development and size, grown under natural conditions, splits both gelatin and Witte's peptone and need not be previously activated by hydrogen cyanide. (Ambros and Harteneck[2], investigating latex of fruits grown in a hot-house, sometimes found activity also towards peptones. The differences between their results and ours will be discussed elsewhere.) The degree of hydrolysis of gelatin falls short of that of peptone. On keeping, the activity of the latex towards gelatin is increased and that towards peptone diminished.

The preparations obtained by us from the natural latex by different methods showed different quantitative, and in some cases different qualitative, enzymic properties. Thus, for example, after extraction of the ether-soluble part of the latex, a solid fraction (I) was obtained which showed all the enzymic features of the fresh latex; several such preparations showed 'full activity' towards peptone and almost the same towards gelatin. 'Full activity' connotes that hydrogen cyanide does not enhance the activity of the preparation. Ether-extracted latex yields by centrifuging two fractions: (i) the supernatant fluid showing the hydrolytic properties of the sap; and (ii) the centrifugate, presenting the enzymic features generally attributed to papain, namely, splitting of gelatin, but no action on Witte's peptone; peptone cleavage and enhanced hydrolysis of gelatin after treatment with hydrogen cyanide. On boiling, the supernatant fluid (i) loses its hydrolytic properties, but it can serve as a specific activator of peptone cleavage. On adding boiled supernatant fluid to the centrifugate (ii), the system becomes effective also towards peptone, whilst its activity towards gelatin is diminished.

Contrary to the literature, true ovalbumin is split directly by a latex preparation.

It appears that the activation (or inhibition) by latex bodies of protein cleavage or peptone cleavage respectively are not identical processes. To account for this, it may be assumed (i) that two different enzymes with different specific activators and inhibitors are present in the latex; or (2) that the natural latex constitutes a complex enzymic system resembling the known 'mixed catalysts'. In these catalysts, certain components, which are themselves not necessarily active, induce new qualitative catalysing properties in the system as a whole. The natural latex, on this assumption, constitutes a complete enzyme system, and is therefore able to perform both hydrolytic functions. On partial or total removal of one or the other of these components—by natural accident, instability or storage, or technique of preparation—differences in quantitative effectiveness or even in specificity are produced.

The results presented above show that the accepted definition of the enzymic effectiveness and specificity of the natural papain requires correction. The accepted view is based on experiments which had, out of technical necessity, to be conducted, in the main, with preparations not fully representative of natural conditions.

A detailed report will be given elsewhere.

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R. MAIMIN.
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Dec. 13.

[1] Willstätter and Grassmann, *Z. physiol. Chem.*, **138**, 184 (1924); Willstätter, Grassmann and Ambros, *Z. physiol. Chem.*, **152**, 164 (1926).
[2] *Z. physiol. Chem.*, **181**, 24 (1929).

Attachment of the Sheep Hookworm to the Common Sheep Tapeworm

THE study of the manner of feeding of the nematodes inhabiting the alimentary canal of vertebrates is one of the comparatively recent developments of helminthology. Hoeppli, Wetzel and others have shown that many nematodes which possess a well-developed buccal capsule—typified in the Strongylidæ and the Ancylostomidæ—are probably tissue feeders. Thus Wetzel[1] describes the feeding habits of *Chabertia ovina* (Gmelin, 1790) from the large intestine of the sheep and says:

"Longitudinal sections of specimens attached to the mucosa show that the worms have drawn a portion of the stratum glandulare into the sub-globular toothless buccal capsule. On its base the tissue is strongly pressed together by the mouth wall and the anterior margin of the buccal capsule, forming a neck-like constriction. Opposite the place to which the parasite is attached a flexure is to be seen in the muscularis mucosa and in the submucosa . . . As to the marked regressive changes

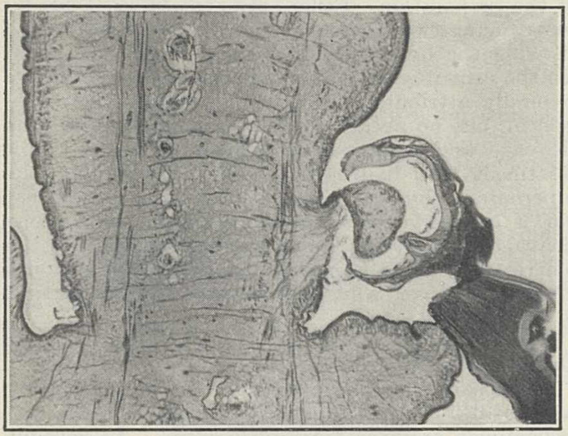

Fig. 1.

of the swallowed tissue and the necrotic masses at the bottom of the buccal capsule we have to assume further a histolytic action of the parasite. . . . From a general physiological point of view the whole process is nothing other than a pre-digestion of the elements of the propria mucosa before they are swallowed by the worm."

On two occasions during the past two years, in the course of frequent examinations of the fresh intestinal contents of sheep for nematodes, I have seen *Bunostomum trigonocephalum*, the sheep hookworm, attached to *Moniezia expansa*, the common sheep tapeworm, though, presumably, it is usual for this hookworm to satisfy its food requirements through the mucous membrane (hæmoglobin may be demonstrated in the worm). In one case, attempted fixation of the parasites to show their relationship was unsuccessful, the *Bunostomum* coming away on immersion in Carnoy, but in the other case the attachment was secure enough to overcome the tendency of the worms to contract on fixation. The accompanying photograph (Fig. 1) illustrates a section through the point of attachment. Although the cestode tissue is badly contracted, seemingly because of the unsuitability of Carnoy as a fixative, it will be seen that the effect of the *Bunostomum* on the cestode tissue is much like the effect of *Chabertia* on the mucous membrane as described by Wetzel. There is a similar withdrawing of a portion of tissue into the buccal capsule, a similar constriction of it at the mouth margin, and a similar tendency, as shown by the transverse muscle fibres, for the deeper lying structures to be drawn down towards the hold of the nematode. Finally, a certain amount of regressive change has taken place in the tissue within the buccal capsule, and the cestode cuticle, the sub-cuticular layer, and the sub-cuticular cells have all been destroyed.

While from this one example, it would be too much to say that *Bunostomum* utilizes *Moniezia* as a source of food, in addition to anything it derives from the mucous membrane, yet the occurrence of this one case has an interesting bearing on the factors which lead the nematodes of the alimentary canal to the mucous membrane. I have so far failed to demonstrate any chemotropic effect the membrane may have on these nematodes, but their possession of a strongly developed stereotropism is readily shown in many ways. They will swim freely in a suitable solution until contact with a membrane surface or its equivalent is attained and then, for some considerable time, they will remain at the surface. Would this stereotropism be sufficient to keep them at the mucous membrane, and is the mere presence of the tissue sufficient stimulus to cause them to feed, or at least, attempt to feed? Or, after all, does the mucous membrane exert a chemotropic effect on the nematodes, and is this particular *Bunostomum* an example of one that has failed to respond?

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[1] Wetzel, R., *North Amer. Vet.*, 12, 9, 25–27 (1931).

Structural Laws of the Mammalian Kidney, with a Theoretical Derivation

THE structural laws to be described, though independent of theory, may be derived from certain general principles arising out of a 'diffusion-pressure' theory of the kidney. This theory has already been developed to some extent[1]. The principles of derivation are as follows:

(*a*) The renal secretory cells are equivalent in action throughout the Mammalia, and their function is to create a diffusion pressure of urea, etc., in the direction of the lumen.

(*b*) The shape of the kidney and the relations of tubule length to renal length remain uninfluenced by body weight.

(*c*) The mammalian kidney is so constructed that the mean blood and urine concentrations remain independent of the size of the animal.

From the first principle, the following equation may be derived:

$$V(C_U - C_B) = P\, C_B\sqrt{Vknl} \quad . \quad . \quad . \quad (1)$$

Here V is urine rate; C_U, C_B are the urine and blood concentrations; l is the length of the secreting tubule; k is the diffusion coefficient of urea, etc., which may be regarded provisionally as the diffusion coefficient through the tissue; P is a constant. As will be shown later, slight modifications make this equation independent of all changes of blood and urine volume.

Derivation of the structural relations and comparison with the actual data.

From (*c*) and equation (1) we have :

$$V = nl \times \text{a constant} \quad . \quad . \quad . \quad . \quad (2)$$

Since the mean concentration of total nitrogen in the urine is also, from (*c*), independent of body size, and introducing the well-known relation of metabolism to body surface, we derive :

$$nl = W^{0 \cdot 666 \cdots} \times \text{a constant} \quad . \quad . \quad (3)$$

From (*a*) we have directly that the secreting cells are independent of the size of the animal, or :

$$d = W^{0 \cdot 000} \times \text{a constant} \quad . \quad . \quad . \quad (4)$$

The mass of the secreting tissue will be proportional to $nl \times d^2$ and since d is constant, from equation (4), the mass is therefore proportional to nl. Since from (*b*) l will be a linear dimension of this secreting tissue, we get from (3) :

$$n = W^{0 \cdot 444} \times \text{a constant} \quad . \quad . \quad . \quad (5)$$

and

$$l = W^{0 \cdot 222} \times \text{a constant} \quad . \quad . \quad . \quad (6)$$

From the first principle (*a*), and equations (2) and (3), it follows that :

$$ng^2 = V \times \text{a constant} = W^{0 \cdot 666} \times \text{a constant} \quad (7)$$

where g is the diameter of the glomerulus.

Hence from (5) we get :

$$g = W^{0 \cdot 111} \times \text{a constant}.$$

Collecting the theoretical relations for the single measurements, we have :

$$\begin{aligned} n &= W^{0 \cdot 444} \times \text{a constant} \\ l &= W^{0 \cdot 222} \times \quad ,, \\ g &= W^{0 \cdot 111} \times \quad ,, \\ d &= W^{0 \cdot 000} \times \quad ,, \end{aligned}$$

The actual relations established by the minimum square error principle from the logarithmic values of measurements on the mouse, rat, rabbit, cat, echidna, dog, sheep, pig, man, horse and cow, from the available data of Peter, Putter, Inouye, Siewart, Moberg, O'Connor and Conway, etc., are :

$$\begin{aligned} n &= 4580 W^{0 \cdot 456} \\ l &= 1 \cdot 78 W^{0 \cdot 196} \\ g &= 55 W^{0 \cdot 109} \\ d &= 50 W^{0 \cdot 006} \end{aligned}$$

where l is length of first convoluted tubule expressed in millimetres and g and d are expressed in microns.

It is hoped to present details shortly in the *Proceedings of the Royal Irish Academy*.

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University College,
Dublin. Jan. 7.

[1] See Conway, E. J., and Kane, F., *J. Physiol.*, **61**, 595 (1926); Conway, E. J., *Amer. J. Physiol.*, **88**, 1 (1929).

Claims of Geology in School Courses of General Science

THE Interim Report of the Sub-Committee of the Science Masters' Association on "The Teaching of General Science" (reviewed in NATURE of December 19; **138**, 1030) will have been read with much appreciation by all who are interested in school science. While this is under discussion it seems appropriate to direct attention to another report, on "The Teaching of Geology in Schools", by a Committee of Section C of the British Association. This latter report will appear in the forthcoming annual volume of the British Association, but unfortunately it was not available in time for consideration by the Science Masters' Sub-Committee. In it, amongst other recommendations, is a strong plea for the inclusion of a certain amount of geology (with physics, chemistry and biology) in all courses of general science. The Science Masters' Sub-Committee decided not to include any geology (or astronomy) in the syllabuses they suggested, "despite their obvious claims to inclusion". This decision will be regretted, at any rate by geologists, but it may be hoped that it is not final. Indeed the definition of general science arrived at by the Sub-Committee encourages the hope that the claims of geology can scarcely be overlooked : it begins, "General Science is a course of scientific study and investigation which has its roots in the common experience of children and does not exclude any of the fundamental sciences".

It is perhaps not yet generally recognized that many geologists regard the present outlook for their subject with grave disquiet, for although geology has never been taught in schools so widely as other sciences, its position in the educational system has recently become far worse than in the past. It is claimed that there are both cultural and utilitarian grounds for teaching it in schools of all types, but the absence of any mention of it in most curricula is leading to a scarcity of students which threatens to affect seriously the quality of professional geologists and to react adversely on teaching and research in the science.

It may, of course, be held that this position is not the concern of the schoolmaster, but it is noteworthy that the Sub-Committee of the Science Masters' Association takes a wider view of the teacher's responsibilities. While it is suggested that the training of experts cannot form a part of a school course, "the pre-preparation of experts" is one of the schoolmaster's tasks, "and this can best be achieved by broadening the syllabus ; for it is at school that particular talents are discovered and their development fostered".

It is hoped that the position of geology in schools, in general science as well as in other courses, may receive sympathetic consideration in the light of the recommendations put forward in the report of the Committee of Section C, for it may be doubted whether one per cent of those who at school receive some training in science have an opportunity to discover any talent for work in geology.

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Jan. 18.

The Hexlet

IN Prof. Soddy's recent article[1], the following expression occurs under the root sign in formula (2) :

$$6(\alpha\beta + \beta\gamma + \gamma\alpha + \alpha\delta + \beta\delta + \gamma\delta) - 3(\alpha^2 + \beta^2 + \gamma^2 + \delta^2).$$

I find that this expression is equal to $27V^2\alpha^2\beta^2\gamma^2\delta^2$, where V is the volume of the tetrahedron whose vertices are at the centres of the four spheres with bends α, β, γ and δ.

Prof. Soddy, on hearing of this relation, suggested to me that the expression might (following the analogy of the inscribed circle in two dimensions) be related to the bend of the inscribed sphere. This does not turn out to be the case. It is, however, related to the sphere which touches the six edges of the tetrahedron and which cuts the four spheres orthogonally at their six points of contact, and is in fact equal to $12\varepsilon^2$ where ε is the bend of this sphere.

The expression does not change its value if we substitute for any of the original four spheres the opposite members of the hexlet touching the remaining three. The same sphere touches the edges of the four other tetrahedrons which can be formed in this way and thus cuts the spheres orthogonally at twelve other points of contact as well as the original six.

THOROLD GOSSET.

Cambridge.
Jan. 21.

[1] NATURE, **139**, 77 (Jan. 9, 1937).

THE beautiful result arrived at by Mr. Gosset thus gives an alternative very simple expression for the bend of any of five spheres in mutual contact, namely, $\sigma/2 + \sqrt{3}\varepsilon$, where σ denotes the sum of the bends of the other four, whilst the volume of the tetrahedron involved is $(2\varepsilon)/(3\alpha\beta\gamma\delta)$. It applies in general to tetrahedra for which the *sum* of opposite pairs of edges is, for all three pairs, the same.

I take the opportunity of recording that the tetrahedra formed by joining the four points of contact of any one sphere with the other four, when five are in mutual contact, have the *product* of opposite edges constant. This much simplified the original solution of the problem, and a proof by inversion has recently been sent me by Mr. Hodgkinson. This product is $4\{(\varphi + \alpha)(\varphi + \beta)(\varphi + \gamma)(\varphi + \delta)\}^{1/2}$ and the volume of such tetrahedra is given by

$$V = \frac{2}{\sqrt{3}}\left[\frac{\varphi}{(\varphi + \alpha)(\varphi + \beta)(\varphi + \gamma)(\varphi + \delta)}\right].$$

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Points from Foregoing Letters

From observations of disturbances of the earth's magnetism accompanying hydrogen eruptions in the sun, A. G. McNish infers that magnetic disturbance may be attributed to a sheet of current in the electrical layer of the upper atmosphere (ionosphere) together with oppositely directed currents in the earth.

A statistical investigation of the time-distribution of rainfall at Diamond Plantation in British Guiana, over a period of twenty years, leads C. H. B. Williams to the conclusion that there is no support for the local view that more rain is likely to fall at the new or at full moon than during the days just before or just after these phases.

Assuming that the components of a double star are parallel magnetic dipoles giving rise to an electric field, Prof. H. Alfvén calculates that energies of the order of 10^{11} electron volts, such as are found in cosmic rays, could be imparted to electrically charged particles.

Graphs showing the change in apparent brightness according to the point of entry of light rays into the pupil of the eye are given by Dr. W. S. Stiles and B. H. Crawford. The authors have also measured the differences in the apparent hue of monochromatic light in the case of central and peripheral entry.

Photographs of the ultra-violet spectra of several stars indicate, according to Dr. T. Dunham, jun., the presence in interstellar space of ionized titanium with a mean life-time up to several weeks. The author discusses these findings in relation to the temperature and mean density of interstellar matter.

D. A. Webb points out that in spectrographic analyses of tissue ash or similar materials, it is easy to mistake impurities in the electrodes used for the arc for constituents of the specimen, even if a blank spectrum of the electrodes is used as a control. This arises from the fact that the spectrum of the impurities may be enormously intensified by the introduction of the ash into the arc. Copper, vanadium and titanium are the elements most likely to give misleading results from this cause.

A table showing the intensity of various bands in the luminescent spectrum excited by the ultra-violet in dilute solutions of terbium salts is submitted by A. Seidel. The author gives a formula for the differences between the frequencies of the seven bands observed and discusses the quantum transition levels which would account for them.

Max Frankel, R. Maimin and B. Shapiro state that the generally accepted view of the hydrolytic properties of papain requires correction. Latex of *Carica papaya* and preparations obtained directly from it, split not only proteins, but also peptones, though papain was supposed to acquire this latter property only by artificial activation. By fractionating the natural latex, several preparations were obtained, among them one which shows all the features generally attributed to papain. Furthermore, a thermostable natural activator inducing peptone cleavage was found. The properties of the various preparations suggest that the natural activation (and inhibition) of protein- and of peptone-cleavage respectively are different processes.

While it is usual for the nematodes of the alimentary canal of vertebrates to attach themselves, firmly or otherwise, to the mucous membrane, D. G. Davey reports an instance in which the sheep hookworm has drawn into its buccal capsule a portion of the common sheep tapeworm. He discusses its bearing on the factors which lead the nematodes to the mucous membrane.

From theoretical considerations, Prof. E. J. Conway has deduced certain relations between the weight of the kidney in mammals and several other factors such as the length of the secreting tubule (l) and the diameter of the glomerulus (g) of the organ in question.

Mr. T. Gosset, continuing the correspondence on the hexlet, states that he has derived a simple expression for the 'bend' of any of five spheres in mutual contact, and Prof. F. Soddy also notes a further development of the subject.

Research Items

Cave Man in Texas, U.S.A.

A JOINT expedition of the University Museum and the Academy of Natural Sciences, Philadelphia, excavated in the Williams Cave, Guadalupe Mountains, Culberson County, Texas, in 1934 and 1935. Dr. E. B. Howard was a member of the expedition in the first year, and in the second Mr. and Mrs. Richard G. L. Ayer, of whom the latter has described the results (*Proc. Acad. Nat. Sci. Philadelphia*, 88, 599). The cave is situated south-west of Signal Peak, the southern termination of the Guadalupe Mountains, two hundred feet up on the side of a steep limestone canyon. Its dimensions are roughly forty feet wide at the entrance and forty-eight feet deep. Three burials were found. The first was in the back half of the northern section eighteen inches below the surface, as was most of the Indian material, and was covered with a large basket, mostly decayed. Two children were found close together, apparently covered with the same netting. The upper skull was covered by a small basket in perfect condition. With this burial were *Olivella* shell and circular pink shell beads. Near were fragments of closely woven cloth and a ball of purple paint. The second was a typical cradle burial, near the north wall. A coarse woven basket was over the burial, and close by fragments of another basket contained painted sotol strips. The cradle was triangular in shape, and the body wrapped in soft hide painted red. This was covered with another piece of hide with the fur on, and over all had been a rabbit fur blanket, now much disintegrated. A bag of charms was on the cradle. The third burial was a bag burial of an adult. The bag was of deer or antelope hide painted red, and contained charred bones. The culture of the archæological remains recovered from the cave corresponds to the Hueco cave dwellers. Twenty-two forms of mammal remains are reported, of which 22·7 per cent are extinct, including the giant sloth. There is evidence of a difference in climate.

Genetics of Cancer

IN the spontaneous development of breast cancer in mice, the genetic factor of the animals and the functional activities of the gonads play important parts. Dr. L. Kreyberg, of Oslo, in the "Reports of the Second International Congress of Scientific and Social Campaign against Cancer" (Brussels, 1936), puts forward the evidence showing that spontaneous breast cancer in mice is in principle equivalent to tumours induced by synthetic carcinogenic agents, the difference being that in the former case the agent is of an intrinsic and physiological origin. The susceptibility to induced tumours and spontaneous breast tumours is genetically different. Work on the genetics of tumour-bearing mice indicates that both chromosomal and extra-chromosomal or cytoplasmic factors are concerned. Dr. Clara Lynch, of the Rockefeller Institute for Medical Research, in a paper in the same volume, shows that the induction of tumours of different types is controlled by different genetic factors, and considers the initial change in carcinogenesis to be of the nature of a somatic mutation. Longevity is important in the development of cancer, and the inheritance of long life as well as susceptibility to mammary cancer and to leukæmia appear to be controlled to a greater extent by the female parent than by the male.

Leeches of the North Sea and Baltic

LIEF. 29, Teil VI.c2 of "Die Tierwelt der Nord- und Ostsee" ("Hirudinea". By Konrad Herter. Akademische Verlagsgesellschaft m.b.H., 1936) contains a very good account of the marine and brackish water leeches of these regions. The marine forms all belong to the Piscicolidæ with the exception of a few visitors, but in brackish waters members of the Glossiphoniidæ, Hirudinidæ and Herpobdellidæ occur. Keys to the sub-orders, families and genera are given and the species belonging to each genus are described and figured. Technique for collecting and preserving follows, with accounts of general anatomy, distribution, movement, nutrition, excretion, respiration, circulation, sense organs, nervous system, reproduction and development. The work is well up to the standard of this most useful series.

Diseases of Garden Plants

THREE fungal parasites of garden plants have been recently described (*Trans. Brit. Mycol. Soc.*, 20, Parts 3 and 4, Nov. 1936). Miss Catherine C. Burt found the fungus *Didymellina dianthi*, a new species, upon the leaves of Sweet William. This name is given to the perfect stage of a fungus the conidial stage of which is known as *Heterosporium echinulatum*. *D. dianthi* is apparently a specific parasite of the Sweet William; carnations and pinks are highly resistant. Mr. N. C. Preston has established the pathogenicity of the fungus *Myrothecium roridum* upon *Viola* plants. It can apparently enter unwounded tissue, and may cause considerable destruction of its host under cultivation. Dr. George Trapp has considered the parasitism of *Botrytis cinerea* on the Japanese laurel, *Aucuba japonica*. The fungus can enter the host through a crack in the cuticle or through a nectary surface, when the atmosphere is completely humid. Symptoms of the disease, and the life-history of the causal organism, are also described.

Lead Arsenate Treatment of 'Leather Jackets'

HOW best to combat the ravages of the crane fly larvæ, commonly known as 'leather jackets', is one of the problems that besets those interested in turf management. Investigations on the subject are being carried out at the St. Ives Research Station, and some of the more recent experiments have recently been described by R. B. Dawson and R. B. Ferro (*J. Board of Greenkeeping Research*, 4, No. 15). The requirements necessary in the ideal material are several. It must not damage the turf, and preferably not even cause a temporary disfigurement; at the same time it must be economical in use, simple to apply and be harmless to human beings and grazing animals. Lead arsenate satisfies many of these conditions, and experiments carried out with it at a number of different centres have given very promising results. Treatment was successful with either the powder or colloidal form, though preference for the former was shown by many of the workers who had the handling of it, and moreover it is cheaper.

Generally as good control was obtained with the lighter as with the heavier dressings, and since lead arsenate is expensive and the areas requiring treatment frequently large, this is a result of economic importance. It is recommended that before embarking on large-scale dressings, periodical treatment with orthodichlorbenzene emulsion should be carried out to determine whether or not the turf contains the larvæ. The lead arsenate should then be applied in powder form at the rate of 1 oz. per sq. yd. (2·7 cwt. per acre) or if worm control is also desired, at the rate of 1½ oz. per sq. yd. Applications should be made by hand or mechanical distributor after bulking with fine soil or other carrier, at any time during autumn, winter or spring, and grazing animals kept off the turf until the arsenate is well washed into the soil, as it has poisonous properties. The larvæ die in the soil, so no labour other than the distribution of the lead arsenate is involved.

Growth of the Tanna Fault in Japan

DURING the destructive earthquake of November 26, 1930, in the Idu peninsula, remarkable displacements occurred along the Tanna fault. This fault runs north and south through the western slopes of the volcanoes that lie near the east coast of the peninsula. The intersection of the fault by the Tanna tunnel at a depth of 525 ft. shows that its plane is inclined steeply to the west. In an interesting memoir (*Bull. Earthq. Res. Inst.*, 14, 619–631 ; 1936), Mr. H. Kuno studies the growth of the fault since the Lower Pleistocene age. He shows that the channels of three rivers on the west side of the fault now lie 1 km. to the south of their former continuations on the east side and that the slope of the ground on the west side, if produced, would lie about 100 m. above the slope on the east. Cutting the map along the line of the fault and shifting the west side through a distance representing 1 km. to the north, and lowering the height of each contour-line on that side by 100 m., the two sides fit well together, except in the northern part of the district, in which the vertical displacement was much less. Mr. Kuno thus concludes that the block on the west side of the fault was shifted about 1 km. to the south over the greater part of the fault and raised 100 m. or more in its southern part, relatively to the block on the east side. It is interesting to notice that the displacement during the Idu earthquake of 1930 was similar, the greatest relative movements of the western block being 1·2 m. to the south and 0·6 m. upward.

Optical Experiments with Pinholes

MR. F. J. HARGREAVES has recently published a paper under the above title in which he describes how the diffraction phenomena produced by telescopes can be reproduced by looking through pinholes of different diameters (*J. Brit. Astro. Assoc.*, 47, 2; December 1936). It is quite easy to see the phenomena of a single star, double stars or even of planets, the latter being simply illustrated by the warp and weft of a piece of fabric remaining invisible through a small pinhole, though easily seen through a large one. The large diffraction pattern in the former case hides the details, and in the same way fine detail on a planet or the moon is invisible in a telescope of small aperture, though easily seen in one of large aperture. The experiments are very clearly described, and users of telescopes will find much that is both interesting and instructive in the paper.

Time Effects in Spectrophotometry

MR. W. M. H. GREAVES has a paper under this title in *Mon. Not. Roy. Astro. Soc.*, Supplementary Number, 96, 9 (October 1936). He points out that Schwarzschild's law, $D = \varphi(It^p)$, where D is the optical density of the image or any other measure of photographic effect, I is the intensity of the light, t the time of exposure, and p the constant for any particular plate, is only a first approximation. The work of Kron and others has shown that it is valid only over a very limited range, and errors occur in spectrophotometric measurements which involve the use of different exposure times, if the law be applied. Mr. Greaves is concerned with applications to practical spectrophotometric technique, and develops simple formulæ which are capable of high accuracy over the limited ranges of the variables employed in practice. Two formulæ are given which correct for time effects, and it is suggested that they may be of assistance to workers who desire to be free from the restriction of using identical exposure times in all comparisons—a procedure which seriously limits the output. When unequal times are used, it is essential that the character of the emulsion should be investigated, and also that the value of a certain constant ε should be determined. No account has been taken of temperature effects in the paper, but from the work of Webb (*J. Opt. Soc. Amer.*, 25, 4 ; 1935) it does not appear that serious errors will be introduced, for ordinary working temperatures, if the variation of ε with temperature be ignored. It is important, however, to calibrate plates at approximately the same temperature as that at which they are to be exposed.

Controlled Grain Size in Steel

IT has been known for some time that by a control of the degree of de-oxidation of molten steel prior to casting, combined with the addition of a small amount of aluminium, steels can be produced with a grain size which is much finer than is normally the case. The majority of the work hitherto published is of American or German origin, and a paper read by T. Swinden and G. R. Bolsover before the Iron and Steel Institute in September last represents the first publication in Great Britain on an exceedingly important subject. The authors show that the fine-grained steel so produced is characterized by a very much higher impact value than is the normal material. In the case of nickel-chrome steels subject to 'temper brittleness', it is shown that these fine-grained steels, although still showing this phenomenon, are less affected than are the steels as ordinarily manufactured. The low-temperature brittleness produced by tempering in the region of 250°–400° C. after a preliminary quenching is less pronounced in the fine-grained steels than in the coarser ones. An exceedingly interesting field is opened up by the proof that these fine-grained steels retain their impact value to a very much greater extent when strained and re-heated to 250° C. than do materials of similar composition but with larger crystal size. The ageing after quenching at 650° C. again does not produce anything like the degree of embrittlement in the new material as obtains with ordinary steels. Cracking during hardening appears to be eliminated or greatly reduced, while the machinability of the 'controlled grain' steel is not appreciably different from that of ordinary engineering materials of similar composition.

Physics of the Solid State

Fiftieth Anniversary of the Physical Society of Zurich

THE Physical Society of Zurich celebrated its fiftieth anniversary by holding a meeting on January 13–16 to discuss the "Solid State".

This Society was originally founded by students in order to discuss physical and technical problems. One of the early and rather unusual rules governing the selection of new members was that no professors should be admitted. This rule was abandoned later when the Society included in its list of members such distinguished names as: P. Weiss, A. Einstein, M. von Laue, P. Debye and E. Schrödinger, who were all at some time on the staff of either the University or the Technical High School in Zurich.

The jubilee meeting was opened by the president of the Swiss Board of Education, and his address was followed by a speech from Prof. P. Weiss, of the University of Strasburg, who represented the foreign members of the Society.

The first scientific address was given by Prof. P. Niggli, of the Technical High School, on the subject of "Mineralogical Problems of Crystal Structure". Prof. Niggli gave first a general survey of the various crystal types and discussed in particular the case in which whole groups of the constituent parts of the crystal are partially substituted by other groups without thereby altering the lattice. He gave the rules governing these substitutions, and discussed the problem on the basis of the geometrical structure theory.

On the following day, Prof. W. L. Bragg, of the University of Manchester, gave an account of the structure of binary alloys in connexion with the Hume-Rothery rule, and discussed the lattice transformation in alloys in their relation to order-disorder phenomena.

Prof. P. Debye, of the Kaiser Wilhelm Institute of Physics, Berlin, dealt in his lecture with the semi-crystalline nature of liquids. He discussed the effect of the waves of thermal agitation in a liquid upon the scattering of monochromatic light by the liquid. Whereas, in a gas, light originally monochromatic becomes slightly less so after it is scattered, in an ideal crystal, this light splits into two components; and in a liquid, generally speaking, into three spectral lines, except when the coefficient of expansion becomes zero, as for example in water of maximum density, where only two lines appear, as predicted by the theory. From these experiments, Prof. Debye concludes that a liquid is, on the whole, much nearer to a solid than it is to a gas.

On the following day, Dr. A. Müller, of the Royal Institution, London, gave a summary of the work on long-chain compounds of the paraffin type. He discussed the relations between the structure and physical properties of these substances and dealt with the problem of crystal transformations.

Prof. H. Mark, of the University of Vienna, lectured on the kinetics of polymerization of certain substances which form very long chains, and gave an account of the elasticity of rubber, which he treated as a problem of statistics of the configuration of these long chains.

The evening lecture was delivered by Prof. A. Sommerfeld, of the University of Munich, who gave an excellent account of the modern theory of the metallic state, and of the specific heat and electrical conductivity of metals.

The final address was by Prof. M. von Laue, of the University of Berlin, who discussed the theory of the "Kossel- and Kikuchi-lines" which are observed when a source of X-rays or electron waves is placed inside a crystalline medium.

The papers presented at the meeting will be published together.

The meeting was well organized and attended, for which the president of the Society, Dr. R. Sänger, was largely responsible. At the same time, there was an informal atmosphere and lively discussion. The meetings arranged by the Physical Society in Zurich nearly every year are now well-known in scientific circles, and provide opportunities for the exposition of recent scientific work in a place convenient for scientific men of all nations. A. M.

International Cancer Research

REFERENCE has already been made in these columns to the Second International Congress of the Scientific and Social Campaign against Cancer which was held in Brussels last autumn (NATURE (1936), **138**, 727). The text of fifty-five reports or reviews which were read at the Congress have now been published*. Each report is given at length in one of the six official languages, while summaries of the reports are given in all six languages. Some of the reports, such as that of Cook, Haslewood, Hewett, Hieger, Kennaway and Mayneord on "Chemical Compounds as Carcinogenic Agents" and that of Reding on "Predisposition and Resistance to Cancer", have good bibliographies, while others have no references. The greater part of the volume is concerned with the biology, diagnosis and therapy of cancer, and there are interesting reviews on the statistical investigation of mortality from cancer in different States and among different races.

The last four papers on the statistics of morbidity and mortality from cancer are from London, Munich, New York and Batavia, and show that the total mortality from cancer is of the same order in almost

* IInd International Congress of the Scientific and Social Campaign against Cancer. Vol. 1. Reports. Pp. xvi+503. (Bruxelles: Ligue Nationale Belge contre le Cancer, 1936.)

all parts of the world. As Dr. Cramer points out, "cancer in man is an experiment carried out on man of which the end results are represented by the cancer mortality statistics, while the beginning of the experiment is unknown". The problem of the cause of cancer is to determine the beginning of the experiment, and hints of this are given by analysis of the statistics. Dr. Bonne gives relative cancer mortality figures for Malays and Chinese in Batavia, Chinese in Singapore, Filipinos in Manila, Japanese in Tokyo and Austrians in Innsbrück. The total mortality from cancer in these groups is of the same order, but the distribution according to sites is quite different. Cancer of the liver, which is rare in Europe, is common in the East, and cancer of the lung is more common in Europe than in the East. The results given in these statistical papers show the magnitude and extent of the fight against cancer.

The fact that these reviews are given by invitation by scientific workers of sixteen different countries indicates how widespread is the effort to combat malignant disease. The report brings together work from research workers in chemistry, histology, medicine, surgery, radiology, geography, and statistics, and will no doubt have a beneficial influence in making workers aware of what is being done in cancer research outside their own fields. It is probably as good a general review of the whole field as can be found, although there are too few illustrations in some parts of the work, and several chemical formulæ are incorrectly represented.

The reports deal mainly with work of the last three years, and if similar publications are produced at each triennial congress, they would continue to improve co-operation between research workers in different countries and sciences.

Historic Flora of Mexico

THE Smithsonian Institution has just received, for study and identification of specimens, part of the celebrated Sesse and Mocino collection of the flora of Mexico, which recently came to light in Madrid after more than a century. The collection was sent by Spanish officials just before the outbreak of the revolution to Dr. Paul Standley, of the Field Museum of Natural History in Chicago, an authority on the plants of Mexico. Dr. Standley has distributed it to American institutions specializing in various plant families represented, for study under his direction.

The story of this collection is one of the most colourful in the history of botanical exploration. In 1787, Charles III of Spain sent to Mexico a botanical expedition headed by Dr. Martin Sesse y Lacasta, the most eminent of Spanish botanists, for the purpose of making a complete collection of the flora of Mexico and setting up a chair of botany in the National University at Mexico City. The lectures of Sesse and his companions aroused the interest of a young Mexican physician, Dr. José Mariano Mocino. He became so absorbed in botany that he gave up his practice, obtained an appointment as a member of the expedition, and for more than twenty years engaged in almost constant exploration. He covered all central Mexico, and made trips so far south as Guatemala and so far north as California. In 1804, Sesse and Mocino went to Spain, where they began to work up their collections. Sesse died five years later, and Mocino was made director of the Cabinet of Natural History in Madrid. About this time, Madrid was invaded by the French. A change in Government meant nothing to the Mexican botanist, absorbed in the plants for which he had risked his life so often. He was popular with the invaders, and they did not disturb him. Then the French were driven out and the vengeance of the Spaniards, incensed at his "traffic with the enemy", fell upon the head of Mocino. He was thrown into prison and placed in chains, to be rescued by the return of the French army.

Once again the French were driven out. This time Mocino took no chances. He loaded his manuscripts and drawings into a mule cart and, old and feeble as he was, walked beside it throughout the hasty retreat across the mountains. He finally arrived safely at Montpellier in France, but nearly blind and penniless. He might have starved had it not been for the friendship of the celebrated Swiss botanist De Candolle. The latter, however, borrowed his drawings and took them with him to Geneva. Mocino in the meantime was negotiating to return to Spain, and finally was assured that he would not be bothered. He wrote to De Candolle asking for the immediate return of his drawings. The result was one of the most extraordinary incidents in the history of botany. De Candolle asked for volunteers—anybody in Geneva with any artistic talent—to copy them as a patriotic duty. The volunteers came—society girls, college students, ministers. Altogether 120 of them were put to work and completed the job in ten days. With his drawings returned, Mocino started back to Spain. In Barcelona he was taken ill and died, giving his drawings to a physician who had befriended him. This man apparently attached no value to them and they disappeared. Had it not been for De Candolle's copies, they would have been lost completely to science.

Meanwhile, the manuscripts of Sesse and Mocino and the plants they had collected remained at Madrid. Nobody attached any value to them or paid any attention to them. It was not until 1888, nearly a century after the collections were made, that the manuscript was published in Mexico City. Meanwhile most of the plants had been rediscovered and described, so that Mocino and Sesse were deprived of their hard-earned glory.

The specimens, however, remained at Madrid. Many of the species described in the manuscript could not be identified with any known in Mexico at the time of the publication, and it was impossible to match the descriptions and other specimens. Perhaps there are species still unknown to science. It is noteworthy that Mocino was especially interested in medicinal plants, and spared no effort to obtain everything to which curative properties were ascribed by natives.

The Pontifical Academy of Science

FEDERICO CESI of the Princes of Acquasparta, John Heck, a Dutchman, Francesco Stelluti of Fabriano and Anastasio de Filiis, Count-Palatino of Terni, founded at Rome on August 17, 1603, an Academy of Science and called it the *Lynceorum philosophorum Ordo seu Consessus seu Academia* with the motto : *Sagacius ista.* Galileo Galilei joined it after 1610.

Finis eius, they proclaimed, *est rerum cognitionem et sapientiam non solum acquirere, recte pieque simul vivendo, sed et hominibus voce et scriptis ubique ullius noxa pacifice pandere.*

Though its fortunes varied, the Academy's aims and activities were always scientific.

In 1847, Pope Pius IX, continuing the interest that previous popes had shown, decided to restore the Academy with a new constitution ; he reconfirmed its possession of the Senatorial Palace on the Campidoglio, began the regular publication of the "Acts", and placed it in direct dependence upon the pope and his government with the new title of the "Pontifical Academy of the New Lincei". Later, in 1877, it was still further enlarged by Leo XIII, who increased the number of its fellows (*Soci*) and began the publication of the "Memorials".

Finally, in 1922, His Holiness Pius XI changed its residence, which after 1870 had been the Palace of the Apostolic Chancellery, to the Vatican Gardens, giving it the beautiful little house of Pius IV which is one of Ligorio's finest works of art, and providing generously for its financial rehabilitation. In 1923, he altered its name to "Pontifical Academy of Science—the New Lincei".

Following the Papal Letter, "*In multis solaciis*" of October 28, 1936, and in view of the great importance attaching to the Academy itself, he decided to adapt it to the new and more obvious needs of the times by providing it with a new constitution and a complete revision of its membership, keeping, however, for its former members their rank of 'fellows'.

This new Academy, "The Pontifical Academy of Science", is directly dependent upon the Pope himself, and is composed of seventy 'Pontifical academicians', appointed by the Pope, belonging to every nation and religion, chosen from among the most famous men of science in the world. To these are added the 'Supernumerary academicians' by reason of their office, and the 'Honorary academicians' by reason of their good services towards the Academy itself. *Ab eis itaque Apostolica haec Sedes id auxilii ac decoris expectat ac praestolatur, cuius hic veluti doctorum hominum Senatus, seu "Scientificus" Senatus, certum portendit auspicium.*

The members of the Academy are as follow :

Presidente, Prof. P. Agostino Gemelli, O.F.M. ; *Segretario,* Comm. Prof. Giuseppe Armellini ; *Tesoriere,* M. se Gr. Uff. Prof. Lepri Giuseppe ; *Bibliotecario,* P. Don Anselmo Albareda, O.S.B. ; *Censori,* S. E. Gr. Uff. Prof. Emilio Bianchi, S. E. Gr. Uff. Prof. Filippo Bottazzi, *Cancelliere dell' Accademia,* Comm. Dott. Pietro Salviucci.

Accademici Pontifici Onorari. Emo Card. Gaetano Bisleti, Emo Card. Eugenio Pacelli, Emo Card. Francesco Marchetti Selvaggiani, P. pe Ludovico Chigi Albani della Rovere, Prof. Pietro De Sanctis.

Accademici Pontifici. Abderhalden, Emil (Halle), Amaldi, Ugo (Roma), Armellini, Giuseppe (Roma), Barrois, Charles (Lille), Bianchi, Emilio (Milano), Birkhoff, George David (Cambridge, Mass.), Bjerknes, Vilhelm Frimann Koren (Oslo), Bohr, Niels (Kopenagen), Boldrini, Marcello (Milano), Bottazzi, Filippo (Napoli), Branly, Edouard (Paris), Buytendijk, F. J. J. (Groningen), Carathéodory, Constantin (München), Carrel, Alexis (New York), Castellani, Aldo (Roma), Colonnetti, Gustavo (Torino), Crocco, Gaetano Arturo (Roma), Cuenot, Lucien (Nancy), Dal Piaz, Giorgio (Padova), Debye, Peter (Berlin-Dahlem), De Filippi, Filippo (Roma), de la Vallée Poussin, Charles (Louvain), Fauvel, Pierre (Angers), Gemelli, Agostino (Milano), Gherzi, Ernesto (Zi-ka-wei, Shanghai), Ghigi, Alessandro (Bologna), Gilson, Gustave (Louvain), Giordani, Francesco (Napoli), Giorgi, Giovanni (Roma), Godlewski, Emil (Krakow), Gola, Giuseppe (Padova), Grégoire, Victor (Louvain), Guidi, Camillo (Torino), Guthnick, Paul (Berlin-Neubabelsborg), Houssay, Bernardo (Buenos Aires), Keesom, Wilhelmus Hendrikus (Leiden), Lemaître, Georges (Louvain), Lepri, Giuseppe (Roma), Levi-Civita, Tullio (Roma), Lombardi, Luigi (Roma), Luigioni, Paolo (Roma), Marconi, Guglielmo (Roma), Mendes Correa, Antonio Augusto (Porto), Michotte, van den Berch Albert (Louvain), Millikan, Robert Andrews (Pasadena, Calif.), Morgan, Thomas Hunt (Pasadena, Calif.), Nobile, Umberto (Napoli), Noyons, Adriaan Karel Marie (Utrecht), Panetti, Modesto (Torino), Parravano, Nicola (Roma), Pensa, Antonio (Pavia), Petritsch, Ernst Felix (Wien), Picard, Emile (Paris), Pistolesi, Enrico (Pisa), Planck, Max (Berlin), Rasetti, Franco (Roma), Rondoni, Pietro (Milano), Lord Rutherford of Nelson (Cambridge), Schrödinger, Erwin (Graz), Sherrington, Sir Charles (Oxford), Silvestri, Filippo (Portici), Sperti, George (Cincinnati, Ohio), Taylor, Hugh Stott (Princeton, N.J.), Toniolo, Renato (Bologna), Tschermak-Seysenegg, Armin (Prag), Vallauri, Giancarlo (Torino), Vercelli, Francesco (Trieste), Volterra, Vito (Roma), Whittaker, Edmund Taylor (Edinburgh), Zeeman, Pieter (Amsterdam).

Accademici Pontifici Soprannumerari. Albareda, Anselmo, prefetto della Biblioteca Apostolica Vaticana ; Gatterer, Aloys, prefetto del Laboratorio Astrofisico della Specola Vaticana ; Mercati, Angelo, prefetto dell' Archivio Segreto Vaticano ; Schmidt, Wilhelm, direttore scientifico del Museo Missionario etnologico lateranense ; Stein, Johann, direttore della Specola Vaticana.

University Events

CAMBRIDGE.—Prof. W. J. de Haas, of Leyden, has been appointed Scott lecturer for the year 1937–38.

Prof. L. T. Hogben will lecture in the Zoological Lecture Room on Wednesday, February 10, at 5 p.m., on "Some Neglected Aspects of the Species Problem".

OXFORD.—The following appointments to professorships have been made : Mr. C. N. Hinshelwood, Trinity College, to the Dr. Lee's chair of chemistry ; Mr. Hugh Cairns, Balliol College, to the Nuffield chair of surgery ; Mr. R. R. Macintosh, to the Nuffield chair of anæsthetics.

Science News a Century Ago

The Ashmolean Society

IN Oxford, on February 6, 1837, at a meeting of the Ashmolean Society, "Mr. Holme of C.C.C. read a paper on the formation and habits of the British aquatic coleoptera, which are included in the sections *Hydradephaga* and *Phithydrida* of Macleay, and exhibited specimens which showed the voracity of some specimens of the genus Dyticus, and concluded by drawing attention of the members to the question whether the mole cricket is able to swim, which Mr. Curtis thinks probable, from the resistance which the thorax and elytra offer to water. Mr. Duncan read a paper, in which he gave an outline of the progressive development of animals from their embryo to their perfect state especially of the frog—of one species of which, the *Rana paradoxa*, he exhibited a specimen in the tadpole state, nearly transformed." (*Athenæum.*)

Of the individuals mentioned in this note, one was presumably Alexander Macleay (1767–1848), F.R.S., the entomologist and colonial statesman, another Philip Bury Duncan (1772–1863), keeper of the Ashmolean Museum in 1826–55, and a third John Curtis (1791–1862), the author of "British Entomology" (1824–39).

Lieut. Wellsted's Exploration of Arabia

AT a meeting of the Linnean Society held on February 7, 1837, the chairman, A. B. Lambert, spoke of the researches of Lieut. Wellsted in Arabia Felix, and said that this traveller had added much to the knowledge of the natural history of the district. He had ascertained the tree producing myrrh, and also the dragon-tree. He had surveyed the northern coast of the Red Sea, where he had many opportunities of confirming the descriptions of Bruce, whom he considered the most accurate traveller in those regions who had ever returned to Europe. Mr. Lambert also exhibited some specimens of manna brought by Lieut. Wellsted from Mount Sinai, considered to be the produce of a tamarisk, which was supposed to be identical with that on which the children of Israel fed in the wilderness.

Aylmer Bourke Lambert (1761–1842), well known for his botanical writings, was an original member of the Linnean Society, while James Raymond Wellsted (1805–42) was an officer in the service of the East India Company.

The Properties of Electricity

ON February 7, 1837, F. W. Mullins, M.P., sent a communication to the *Philosophical Magazine* (**10**, 281) entitled "On the Development and Action of Electricity in Voltaic Combinations". In his concluding paragraph he said : "I believe light, as well as heat, to be a property of electricity, else, how account for its existence in its *purest form in vacuo*, where electricity is the only agent ? But I shall refer to these subjects again and at greater length when I have more leizure than I have at present, merely adding that I do not believe my views to be irreconcilable with Mossotti's theory, and that I am quite satisfied that though chemical action may be supposed to develop electricity, still electricity is the prime mover ; electrical and material attractions and repulsions, when brought into play by certain arrangements of elements, inducing and creating all chemical phenomena. . . ."

Heat Transfer in Locomotive Boilers

AT a time when the caloric theory of heat still held sway, Jacob Perkins, on February 7, 1837, read a paper to the Institution of Civil Engineers entitled "On Locomotive Engines and the means of Supplying them with Steam". The practical defects of the existing system of locomotives arising from the furring up or burning out of the tubes of the boiler, he considered, could be overcome through the medium of steam surcharged with caloric. If a tube hermetically sealed be filled to a sixtieth of its contents with water, the steam arising from the water will not acquire sufficient elastic force to burst the tube ; but will have a remarkable property of transferring heat. The steam in the vertical tube being saturated with heat, becomes a medium through which the heat ascends by its own levity, so that the tube would become red hot were it not immersed in water.

Perkins, who was born in America in 1766 and died in London in 1849, was a pioneer in the use of high-pressure steam, and had before 1837 constructed boilers and engines working at pressures of 800–1,600 lb. per sq. in.

Science News in the *Athenæum*

IN its issue of February 11, 1837, the *Athenæum* gave the following notes of scientific interest.

French Academy of Sciences. M. Becquerel is elected vice-president of the French Academy of Sciences for 1837, by a large majority of votes ; and M. Magendie, the last vice-president, passes on to the presidency. The Minister of the Interior has commanded a bust of the late celebrated botanist, M. de Jussieu, to be executed for the Academy, by the skilful hands of M. David.

Acoustics. MM. Cagniard Latour and Demonferrand have invented an instrument which they propose naming the Acoustic Pyrometer, and which will emit sounds according to the temperature in which it may be placed.

M. Melloni. The able and celebrated philosopher, M. Melloni, who was exiled from Italy, has been recalled by the Duchess of Parma : M. Arago appealed to Prince Metternich on his behalf, at the same time laying before His Highness an analysis of his merits, and his beautiful discoveries. The Prince submitted this statement to the Duchess and interceded, and consequently M. Melloni is now at liberty to return to his native country.

Societies and Academies

London

Royal Society, January 28.

R. D. PRESTON and W. T. ASTBURY : The structure of the wall of *Valonia ventricosa*. The cell wall of *Valonia ventricosa* has been studied in detail by means of X-ray diffraction photographs and the polarizing microscope. It consists of layers in which the cellulose chains in any one layer are inclined to those in the preceding and subsequent layers at an angle which is on the average rather less than a right angle. The chains of one set of layers form a system of meridians to the wall, while those of the other set build a system of spirals closing down on the two 'poles' defined by the meridians. The development of the rhizoids is associated with regions of the wall adjacent to the poles of the spiral. The plane of spacing, 6·1 A., of the cellulose crystallites is, roughly speaking, confined within an angle of about 60° to the wall surface. The path of the cellulose spiral is that of a logarithmic (equiangular) spiral described on the surface of a sphere or prelate spheroid.

W. D. WRIGHT: The foveal light adaptation process. A further series of observations on adaptation phenomena have been recorded by the binocular matching method, in which effects induced by light-adapting the right eye are measured relative to the constantly dark-adapted left eye. For white adaptations, the sensitivity of the red and green responses is inversely proportional to the adaptation intensity, and the recovery curves for these responses are linear; for the blue, the response is reduced to a less extent than for the red and green, and the recovery curves are non-linear. They may indicate a monomolecular or bimolecular reaction, whereas the red and green processes appear to recover at a constant rate. With red adaptations, the green recovery is linear and the red non-linear, but while the red sensitivity is inversely proportional to the adaptation intensity, the green is reduced to a relatively less extent as the adaptation is increased. With green adaptations, the reverse occurs. The application of the method of observation for clinical purposes is suggested and the relation of the results to illuminating engineering problems emphasized; in particular, an 'adaptation factor' should be measured in heterochromatic photometry, if the true visual efficiency of light sources is to be found.

W. S. STILES and B. H. CRAWFORD: The effect of glaring light source on extrafoveal vision. The smallest difference of brightness between a test object and its background such that the presence of the object can just be detected (the liminal brightness increment) is in general raised if there is an unshielded light source in the field of view. If the light source produces an illumination E ft. c. at the eye and is located at a point $\theta°$ from the test object, then for foveal vision of the test object the increase in the liminal brightness has been found to be equal to that which would be produced in the absence of the light source by raising the background brightness from its original value B to the value β, where $\beta = B + kE/\theta^n$ and k and n are constants having values approximating to 10 and 2 respectively. Tests were made to see if a similar formula applies when the test object is viewed by extrafoveal vision. Four extrafoveal points situated at approximately 5°, 10°, 25°, and 50° from the fovea in the temporal, lower, upper, and nasal meridians respectively, were studied for two subjects. The formula was found to be true, in general, as an approximation, and for k and n the values 16 and 2 respectively were derived as representative for extrafoveal vision.

Dublin

Royal Irish Academy, December 14.

J. J. NOLAN and P. J. NOLAN: Atmospheric electric conductivity and the current from air to earth. Measurements were made at Glencree of the field and air-earth current by C. T. R. Wilson's method. Hence the conductivity at the earth's surface was determined. Simultaneous observations of the concentrations of positive and negative ions were made. The mean mobilities of the ions were determined. Values of the total conductivity calculated from the results found exceeded by only about ten per cent the values derived from the Wilson experiment.

Edinburgh

Royal Society, January 11.

F. FRASER DARLING: Observations on animal sociality. Animal sociality is difficult to define because of widely differing foundations and the existence of different types within one species. Red deer show closely-knit female groups, loose stag companies and, at the breeding season, harem formations superimposed on the hind groups. The matriarchal system emerging is an evolutionary advance on small patriarchies in grazing herds. Flocking of birds is found outside or within the breeding season. Flocks on a traditional family basis are rare. Observations on herring gull colonies showed that egg-laying was earlier and time taken less in the larger colonies. This was reflected ecologically in the higher survival rates in larger groups.

H. S. RUSE: The geometry of Dirac's equations and their expression in tensor form. Associated with Dirac's equations for general relativity, as obtained from the theory of two-component spinors, are four null vectors which may be regarded as defining the vertices of a skew quadrilateral upon a quadric surface in a three-dimensional projective space. A study of this simple geometrical configuration throws light upon the relationships of the various tensors associated with the Dirac theory, the whole of which can be thrown into a tensor form not explicitly involving spinors.

Moscow

Academy of Sciences (*C.R.*, 4, No. 2; 1936).

J. DUBNOV and N. EFIMOV: Pairs and bundles of grids.

M. M. GUREVIČ: Change in the brilliancy of a bundle of rays on refraction.

N. IVANOVA: Route of the particles comprising the showers of ultra-penetrating rays.

W. A. OSIPOV-KING: A new mode of construction of polarization prisms.

L. M. SCHAMOVSKIJ: The elementary photographic process in ion crystals.

F. M. ŠEMJAKIN: The question of periodic reactions.

A. POLESICKIJ: The lower limit of the formation of mixed crystals of a new type.

W. A. DEVJATNIN: A chemical method for the determination of vitamin B_1.

O. E. ZVIAGINCEV and E. L. PISARŽEVSKAJA: Action of sulphide minerals on solutions of gold and platinum salts.

A. I. ZUITIN and V. V. IVANOVA: Some data on the structure of the testes in hybrids of yak and cattle.

M. CH. ČAJLACHJAN: New facts in support of the hormonal theory of plant development.

A. L. BEHNING: Caspian Peracaridæ in the Manytch basin.

E. M. KROCHIN and F. V. KROGIUS: The lake form of *Oncorhynchus nerka* from Lake Kronotsk, Kamchatka.

G. M. RALL: Character of the propagation of certain rodents as a factor of their numbers in Nature.

N. V. NASSONOV: (1) Influence of various factors on morphogenesis following homotopical subcutaneous insertions of cartilage in the axolotl. (2) Morphogenesis following heterotopic and heteroplastic insertions of cartilage under the skin of the axolotl.

Forthcoming Events

[*Meetings marked with an asterisk are open to the public.*]

Monday, February 8

UNIVERSITY OF LEEDS, at 5.15.—Dr. J. Hammond, F.R.S.: "Growth and the Function of the Mammary Gland".*

Tuesday, February 9

ST. MARY'S HOSPITAL MEDICAL SCHOOL, at 5.30.—Prof. E. D. Telford: "Some Disorders of the Peripheral Circulation" (succeeding lectures on February 16 and 23).*

Wednesday, February 10

BEDFORD COLLEGE FOR WOMEN, at 5.15.—Dr. Friedrich Zeuner: "The Climate of the Countries adjoining the Ice-Sheet of the Pleistocene".*

ROYAL SOCIETY OF ARTS, at 8.15.—Olaf Bloch: "Applications of Photography to Scientific and Technical Problems".

Thursday, February 11

INSTITUTION OF CIVIL ENGINEERS, at 6.—H. Coyne: "The Construction of Large Modern Water Dams" (Joint Meeting with the British Section of the Société des Ingénieurs Civil de France and the Institution of Structural Engineers).

ROYAL AERONAUTICAL SOCIETY, at 6.30—(at the Royal Society of Arts, 18 John Street, Adelphi, W.C.2).—F. W. Meredith and P. A. Cooke: "Aeroplane Stability and the Automatic Pilot".

Friday, February 12

ROYAL ASTRONOMICAL SOCIETY, at 5.—Annual General Meeting.

J. H. Reynolds: Address on the award of the Gold Medal to Dr. Harold Jeffreys.

ROYAL INSTITUTION, at 9.—Prof. I. M. Heilbron, F.R.S. "Pigments Associated with the Fatty Tissues of Plants and Animals".

Appointments Vacant

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:

ENGINEERING INSPECTOR in the Roads Department of the Ministry of Transport—The Establishment Officer, Ministry of Transport, Whitehall Gardens, S.W.1 (February 11).

HEAD OF ENGINEERING DEPARTMENT in the North Staffordshire Technical College—The Clerk to the Governors, Town Hall, Hanley, Stoke-on-Trent (February 17).

LECTURER IN PHYSICS AND MATHEMATICS in the Croydon Polytechnic—The Education Officer, Education Office, Katharine Street, Croydon (February 27).

DIRECTOR OF ANTIQUITIES, Palestine—The Director of Recruitment (Colonial Service), 2 Richmond Terrace, Whitehall, S.W.1 (March 31).

ANALYST AND DEMONSTRATOR at the Harper Adams Agricultural College, Newport, Shropshire—The Principal.

CHIEF CHEMIST of the Indian Jute Mills Association, Calcutta—S. G. Barker, 191 Coombe Lane, Wimbledon, S.W.20.

Official Publications Received

Great Britain and Ireland

British Commonwealth Scientific Conference, London, 1936. Report of Proceedings. (Cmd. 5341.) Pp. 74. (London: H.M. Stationery Office.) 1*s*. 3*d*. net. [141

Report for 1936 (No. 49) of the Marine Biological Station at Port Erin, Isle of Man. Drawn up by Prof. R. J. Daniel. Pp. 25. (Liverpool: University Press of Liverpool.) 1*s*. 6*d*. net. [141

City and County of Newcastle upon Tyne. A Study of the Diets of Sixty-nine Working Class Families in Newcastle upon Tyne. Pp. 45. (Newcastle upon Tyne: City Health Department.) 1*s*. [141

Other Countries

Verhandlung der Schweizerischen Naturforschenden Gesellschaft. 117 Jahresversammlung vom 28 bis 30 August 1936 in Solothurn. Pp. 451. (Aarau: H.R. Sauerländer und Co.) [111

U.S. Department of Agriculture. Circular No. 246: Life History and Control of the Asiatic Garden Beetle. By H. C. Hallock. Revised by I. M. Hawley and H. C. Hallock. Pp. 20. 5 cents. Circular No. 407: Plowing as a Means of Destroying Wireworm Pupæ in the Pacific Northwest. By F. H. Shirck. Pp. 8. 5 cents. Technical Bulletin No. 541: Deterioration of Book and Record Papers. By T. D. Jarrell, J. M. Hankins and F. P. Veitch. Pp. 20. 5 cents. (Washington, D.C.: Government Printing Office.) [111

Conseil Permanent International pour l'Exploration de la Mer. No. 16: Faune ichthyologique de l'Atlantique nord. Publiée sous la direction de Prof. Joubin. Pp. 48. (Copenhague: Andr. Fred. Høst et fils.) 4.00 kr. [111,

Proceedings of the Academy of Natural Sciences of Philadelphia. Vol. 88. Zoological Results of the George Vanderbilt African Expedition of 1934, Part 6: Birds. By Witmer Stone. Pp. 529–598. The Archæological and Faunal Material from Williams Cave, Guadalupe Mountains, Texas. By Mary Youngson Ayer. Pp. 599–619. (Philadelphia: Academy of Natural Sciences.) [111

Memoirs of the Faculty of Science and Agriculture, Taihoku Imperial University. Vol. 18, No. 4 (Mathematics, No. 20): On a Pair of Surfaces Mutually Related, 5. By Sôzi Matumura. Pp. 95–132. Vol. 18, No. 5 (Mathematics, No. 21): Über Flächen und Kurven, 17; Beiträge zur Geometrie der Kreise und Kugeln, 17. Von Sôzi Matumura. Pp. 133–164. (Taihoku: Taihoku Imperial University.) [121

Proceedings of the California Academy of Sciences, Fourth Series. Vol. 22, No. 1: The Templeton Crocker Expedition to Western Polynesian and Melanesian Islands, 1933. No. 30: Diptera. By C. H. Curran, with the collaboration of C. P. Alexander and E. T. Cresson. Pp. 66+2 plates. (San Francisco: California Academy of Sciences.) [131

Bulletin of the American Museum of Natural History. Vol. 72, Art. 5: The Distribution and Habits of Madagascar Birds; Summary of the Field Notes of the Mission Zoologique Franco-Anglo-Américaine à Madagascar. By A. L. Rand. Pp. 143–499. Vol. 72, Art. 6: Some Muridæ of the Indo-Australian Region. By G. H. H. Tate. Pp. 501–728. (New York: American Museum of Natural History.) [131

University of Illinois: Engineering Experiment Station. Bulletin No. 287: The Biologic Digestion of Garbage with Sewage Sludge. By Prof. Harold E. Babbitt, Benn J. Leland and Fenner H. Whitley, Jr. Pp. 112. 1 dollar. Circular No. 27: Papers presented at the Twenty-third Annual Conference on Highway Engineering held at the University of Illinois, February 26–28, 1936. Pp. 160. 50 cents. Reprint No. 9: Correlation between Metallography and Mechanical Testing. By Herbert F. Moore. Pp. 24. 20 cents. (Urbana, Ill.: University of Illinois.) [131

Loris: a Journal of Ceylon Wild Life. (Published by the Ceylon Game and Fauna Protection Society, Gammaduwa.) Vol. 1, No. 1, November 1936. Pp. 60. (Colombo and London: The *Times of Ceylon* Co., Ltd.) 2*s*. 6*d*. [141

Calendario del Santuario e delle Opere di Beneficenza Cristiana di Pompei, 1937. Pp. 200. (Pompei: Scuola Tipografica Pontificia.) [161

Ceylon. Part 4: Education, Science and Art (D). Administration Report of the Acting Director of Agriculture for 1935. By Dr. J. C. Hutson. Pp. 105. (Colombo: Government Record Office.) 1.10 rupees. [181

Ministry of Agriculture, Egypt: Technical and Scientific Service. Bulletin No. 167: Control of Barley Diseases. 2: Loose Smut and Leaf Stripe. By G. Howard Jones. Pp. ii+21+12 plates. (Cairo: Government Press.) 4 P.T. [181

The Imperial Council of Agricultural Research. Miscellaneous Bulletin No. 13: Two New Statistical Tables based upon Fisher's '*t*'. By M. Vaidyanathan. Pp. ii+14. (Delhi: Manager of Publications.) 6 annas; 3*d*. [181

Herbertia. Vol. 3. Dedicated to Arthrington Worsley. Edited by Hamilton P. Traub. Pp. 160. (Orlando, Fla.: American Amaryllis Society.) [191

National Geographic Society. Contributed Technical Papers, Stratosphere Series, No. 2: The National Geographic Society—U.S. Army Air Corps Stratosphere Flight of 1935 in the Balloon *Explorer II*. Pp. 278. (Washington, D.C.: National Geographic Society.) 1.50 dollars. [191

Iowa Geological Survey. Technical Paper No. 3: Iowa Coal Studies By Prof. H. L. Olin. Pp. 80. (Iowa City: Iowa Geological Survey.) [201

Michigan State College of Agriculture and Applied Science. Agricultural Experiment Station Report, Two Years ended June 30, 1936. Pp. 61. (East Lansing: Michigan State College of Agriculture.) [201

Catalogues, etc.

Catalogue of Rare Books and Manuscripts. (No. 208.) Pp. 36. (Leicester: Bernard Halliday.)

Vacuum Thermocouples. (Vac. 36.) Pp. 4. Thermal Compressor for Pressures up to 1000 Atm. (Com. 36.) Pp. 4. (Delft: P. J. Kipp and Zonen; London: W. Edwards and Co.)

A Supplement of Scientific Books. No. 3, 1937. Pp. 20. (Cambridge: W. Heffer and Sons, Ltd.)

Kodak Recording Films and Papers. Pp. 8. (London: Kodak, Ltd.)

Industrial Organisation and Management: a Selection of Books to Borrow. Pp. 4. (London: Management Library.)

Sale List of Chemical Apparatus. (GT 1180.) Pp. 8. (London: Griffin and Tatlock, Ltd.)

The B.D.H. Guide to the Addendum 1936 to the B.P. 1932. Pp. 12. (London: The British Drug Houses, Ltd.)