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Science and Publicity.

IN his presidential address to the British Association on Wednesday last, on the electrical structure of matter, Sir Ernest Rutherford dealt with a subject of fundamental scientific importance, as well as of popular interest—possibly on account of the conception of flying atomic projectiles and their disintegrating effects. The Association thus opened its proceedings this year with a discourse which is likely to make a wide appeal. Whether members of the general public who have not themselves made scientific observations or experiments can have an intelligent comprehension of the true inwardness of work and theory on atomic structure, or on many of the other intricate subjects dealt with in presidential addresses and papers presented to the various Sections, may perhaps be doubted; but even if the mental grasp be weak and the picture induced be primitive, the mere existence of a respectful attitude and receptive mind towards scientific studies is not to be despised.

In the main, of course, the Association is an assembly of scientific workers, most of whom have no wish to discourse to the laity and no capacity for transforming the special vocabularies of their subjects into the simpler—not to say sensational—forms required by many general readers. It ought to be gratefully recognised, however, that the lay writer who is sufficiently well informed to be able to present a scientific subject in attractive literary style, and accurately as well, is performing a useful purpose for science. The investigator who can do this for advances to which he has himself contributed, and on which he is an authority, can always find a generous welcome on platform or in the periodical press, but it is rarely that the faculties of research and exposition are so closely combined; and it may be just as well that they are usually separated. The first business of the man of science is to discover—to add to the sum of natural knowledge; and if he describes his work clearly and in terms which are intelligible to other investigators, he has done his part. It is really supererogatory for him to take up the task of enlightening—or entertaining—a public unfamiliar with even the alphabet of the language of the branch of science in which he works. He may be able to interest members of the British Association, because most of them are engaged in scientific work of one kind or another, and the rest scarcely expect to listen to childish discourses; but the crowd in the street is not within his ambit. The active scientific investigator might appropriately apply to those outside his gates the words, "I have yet many things to say unto you, but ye cannot bear them now." Science does not need to be sought with a contrite heart, but it does demand a certain amount of preparation from all who would understand the full meaning of the treasures within its temples.

So far as it is possible for men of science to offer popular expositions of subjects on which they are creative authorities, this is done in the Citizens Lectures now delivered at each meeting of the British Association and on a more extended scale than usual at this year's meeting. These lectures are not intended for members of the Association but for the general public, and the large audiences which attend them show that very many people are interested in simple accounts of scientific work and progress in certain fields. Such descriptive lectures, however, do little more than titillate the minds of most of the hearers, and nothing to impress them with the conviction that science is the greatest social factor in modern civilisation. Wonder may be excited by experiment and exposition, but it needs to be associated with confidence in the guidance which science can give if our social and industrial conditions are to derive the best advantages from progressive knowledge. At least one of these public lectures should be devoted each year to the advocacy of science and scientific methods in national affairs, instead of making them all informative displays of achievements in selected fields.

Outside the Section rooms (where scientific workers may be permitted to use their own forms of technical expression) and beyond the lecture halls (where experienced speakers successfully hold the attention of assemblies of citizens) is the general public as a whole, reading the daily and weekly newspapers and expecting to be informed in its own language of important scientific developments of all kinds, however intricate they may be—as, for example, the constitution of the atom, the quantum theory, the principle of relativity, or the significance of cell structure. To provide this great group with the pabulum it is capable of digesting is a task which most research workers prefer to leave to others; and rightly so. Good service is, however, rendered to science by writers who can present difficult subjects in attractive literary form without departing essentially from permissible limits of accuracy—large though these may seem to be to precise investigators. There are such contributors to the general periodical press, and we think that every encouragement and assistance should be given to them. The more that the public is made to understand the fertility and the power of science the greater will be the trust in scientific service, and provision for scientific study and research will be correspondingly increased.

In the British Isles, little attempt has been made to secure wide publicity for scientific institutions and work, with the result that they are almost unknown outside scientific circles. The publications of the National Physical Laboratory, for example, are altogether inadequate to give even industrialists an idea of the work carried on in that institution. On the other hand, the U.S. Bureau of Standards issues frequent Bulletins dealing broadly with topics in which practical men are interested and in which developments have recently taken place. The U.S. National Research Council also publishes a number of useful Bulletins surveying the state of knowledge of various scientific subjects and bringing together important data. No institution or society in the British Isles issues anything comparable with these Bulletins: most of them seem, indeed, to be content to hide their light under a bushel, so far as the outside world is concerned, and to discourage any attempts made to extend the zone of illumination.

We do not suggest that scientific and technical societies should add a publicity service to their functions: they are primarily intended for the reception and discussion of new contributions to knowledge, and their concern is the interests of their fellows rather than the attention of the public. The British Association is on a different footing, in that no technical qualification is required for membership and that it sets out deliberately to create interest in science in the centres where the annual meetings are held, and beyond them by the reports of its proceedings. The presidential addresses, published annually for the Association by Mr. John Murray under the title "The Advancement of Science" (price 6*s.*), though often somewhat special in style and scope, constitute the best annual record of the position of scientific subjects of prime importance. Probably few men of science are capable of following intelligently all the subjects reviewed in these addresses, and the general public may therefore be pardoned for not comprehending most of them. To students of science, however, whether as a professional occupation or as a leisure hour pursuit, the addresses are invaluable as authoritative statements of scientific fact and theory, and the volumes containing them should be in the library of every one who finds satisfaction in pondering over the great problems with which modern science deals.

Though the British Association welcomes membership from the general public, it is not too much to say that the presidential addresses, and most of the papers presented to Sections, are intended for audiences of special scientific workers. In the case of a body like the British Medical Association, membership is limited to professionally qualified men, and in the Sections, therefore, no attempt need be made to deal with scientific subjects in popular terms. With its mixed membership, however, the British Association is in a different—and also more difficult—position. Interpreters are needed, if not in the Section rooms themselves, then in the public press. Leading newspapers prefer that their own correspondents or contributors should perform this function, but there are many others which would gladly make use of notes and articles on scientific subjects suitable for the general reading public.

In the United States an institution entitled "Science Service" was established a year or so ago to provide such popular articles as a scientific news syndicate, and it now supplies about fifty American newspapers, and several in Canada and other parts of the world, with news Bulletins sent from Washington every day except Sunday. "The first consideration in a Bulletin story," says a circular of instruction to writers of articles, "is to tell of or interpret a scientific event. But the news stories must be so well written that large national newspapers will use them without rewriting or revision, either in form or language. Write your story so that those who know nothing about science will understand and want to read it. Weave in the scientific background that the man in the street does not have. Use simple words. Make your story as graphic as if you were talking about it." It is pointed out, in addition, that "'By Science Service' must stand for accuracy of content and implication."

In order to establish this publicity agency for science, a generous benefactor gave the sum of one million dollars to a Board of Trustees which includes among its members several of the most distinguished men of science in the United States. The whole field of scientific activity everywhere is covered by "Science Service," and the Bulletins are first-rate examples of what can be done to present scientific progress in popular and yet accurate form. We understand that the demand for the Bulletins from newspapers is now sufficient to make this admirable news agency practically self-supporting.

Here, then, we have an excellent example of what can be done successfully for the popularisation of science; and it is obvious that the constitution and methods of such an organisation are very different from those of the British Association, though the aims of both are "to promote general interest in science and its applications." We believe that the National Union of Scientific Workers contemplates establishing a similar scientific news agency to that of "Science Service," and a beginning has already been made by the British Science Guild by the issue of Publicity Pamphlets sent to the newspaper press for reproduction in whole or in part without payment. Since January 1921, the Engineering Foundation of New York has been issuing a series of such "Research Narratives," each containing the story of some research, discovery, or notable achievement in science or engineering. In one form or another these narratives have found their way through practically the entire range of the public press in America as well as the technical journals.

It is clear, therefore, that we in the British Isles are much behind the United States in the provision made for publicity for science. Our scientific societies are second to none, and the number and value of papers published by them are higher now than ever they were, yet no adequate agency exists to extend the knowledge of this work beyond scientific circles and thus to create in the public mind a feeling of pride in our scientific achievements. A great opportunity awaits the benefactor who will provide a liberal sum to establish a British science publicity service comparable with what has proved so effective in America. Political, social, religious, temperance, labour, and scores of other organisations regard it as a duty to carry on their propaganda by means of leaflets and like publications, but science is content to keep its message to itself. It is no wonder, therefore, that the community understands so little of the value and meaning of science. Let us hope that means will soon be forthcoming to establish a bureau which will not only make the proceedings of annual meetings of the British Association widely known and easily intelligible, but will also, throughout the year, continue to interpret scientific advances to a world eager to learn of them but unacquainted with the technical vocabularies in which they are commonly expressed.

Science and Man.

Science and Civilization. Essays arranged and edited by F. S. Marvin. (The Unity Series, VI.) Pp. 350. (London: Oxford University Press, 1923.) 12*s.* 6*d.* net.

THE history of science is by no means a record of steady progress. It was born among the Ionian Greeks, who were the first to speculate intelligently, on the basis of observed facts, "how things grow" and "how they behave," these being the meanings of their two words *physis* and *nomos*, so inadequately represented by *natura* and *lex*. It is often said that Greek science was unsound, being based on brilliant guesswork instead of careful investigation. The Greeks certainly loved bold and sweeping generalisations, but modern biologists, including Charles Darwin, have thought no praise too high for Aristotle, and the achievements of Greece in mathematics, astronomy, and medicine are now held to be scarcely less notable. It must, however, be admitted that the ancients were handicapped by the want of scientific instruments, and that their backwardness in invention was partly due to an erroneous standard of values. If European nations still think it a finer thing to be an orator than a scientific inventor, that is a prejudice which we owe to the Greeks.

The Roman "steam-roller" was not favourable to originality and intellectual progress. After Galen (about A.D. 200) a Sahara of scientific barrenness begins, a dreary waste from which European history emerges only in the sixteenth century. Neither Hellenistic philosophy nor Catholic Christianity did anything to stop this barbarisation, the inevitable result of the long orgy of superstition, massacre, and pillage which we call the Dark Ages. Mankind cannot afford to forget that a measure of stability in political and social conditions is necessary not only for progress but also for the preservation of the gains of the past. The seven hundred years which followed the break-up of the Western Empire might have been blotted out of history without any great loss.

The greater part of Mr. Marvin's excellent volume of essays is devoted to modern problems. The writers admit frankly that the materialistic trend of science in the nineteenth century was the result of its unequal development. Biology advanced more quickly than psychology, and the sciences of inorganic nature were ahead of biology. The tendency to reduce life to mechanism is being abandoned in response to protests from science itself, and the problems of conscious life are seen to involve metaphysical questions with which the older generation hoped to dispense.

Prof. Whitehead, as is well known, thinks that the theories of Einstein will have a revolutionary effect on our conceptions of space and time. "The whole synthesis of the seventeenth century has to be recast. Its time, its space, and its matter are in the melting-pot—and there we must leave them." It will take many years before this judgment can be either affirmed with confidence or denied. There is reason to think that at present Continental thinkers are not prepared to go quite so far as Prof. Whitehead and his friends. There is no doubt that Einstein has made a great mathematical discovery; but we may be permitted to doubt whether a mathematical discovery is likely to give us a new philosophy.

Prof. Arthur Thomson deals judiciously with post-Darwinian biology, and does not talk, as some are rashly doing, about "the abandonment of natural selection." But I cannot agree with him when he says that "no conflict should be possible between religion and science, unless we try to speak two languages at once," or that "scientific and religious concepts are incommensurable." The assumption which underlies such statements is that science deals with facts and religion with values, and that it is possible to keep these two aspects of reality apart. I maintain, on the contrary, that a fact without value is no fact, and a value without fact no value. The two cannot be separated, and the salutary rivalry of scientific and religious truth must continue as long as men take both seriously. It will not do for science to say to religion, "Leave me alone and I will leave you alone."

Mr. Julian Huxley's long essay on science and religion takes a different line. It is interesting not only for the discussion on the place which science can find for the conception of God, but for the confident tone in which the author declares his conviction that the organic is evolved from the inorganic, through the development of colloids from smaller molecules. "Thus the forms of life, simple at first, attained progressively to greater complexity; mind, negligible in the lower forms, became of greater and greater importance, until it reached its present level in man." Mr. Huxley would not maintain that this theory has been demonstrated; but it seems probable that the monistic view of the structure of the universe will in time be generally accepted. The alternative theory that animated spores came to the earth from other bodies gives no explanation of the origin of life, and has difficulties of its own.

I am less satisfied with this writer's attempt to justify a theistic philosophy by setting the progress which he finds to be the law of organic evolution against the pessimistic conclusion based on the second law of thermodynamics. For even if we assume that increasing complexity in living organisms carries with it increasing value, the phase of evolution through which life on this planet is passing is but a transitory episode, which will probably be followed by a reverse process of involution, when our globe becomes less favourable to the higher forms of life. In any case, planetary progress can be only a backwash in the universal current which, if the aforesaid law is true, is carrying all matter towards immobility and final death. No satisfying theism can be erected on this basis. It would surely be better to assume that whatever power wound up the clock once can wind it up again, and that the life of the universe is perpetual, as its Creator is eternal. We are then free to believe in a God whose being is above the recurrent births and deaths of stellar systems.

Mr. Marvin, however, pins his faith on progress in time, and ends the book with a characteristic editorial chirp. It is probably true, as he says, that humanity is still young, and capable of achievements still undreamed of. Hope for the future is reasonable, so long as we do not make a religion of it.

W. R. INGE.

The Manufacture of Acids and Alkalis.

The Manufacture of Acids and Alkalis. By Prof. George Lunge. Completely revised and rewritten under the Editorship of Dr. A. C. Cumming. Vol. 1: *Raw Materials for the Manufacture of Sulphuric Acid and the Manufacture of Sulphur Dioxide.* By W. Wyld. Pp. xiii+558. 36*s.* net. Vol. 5: *The Manufacture of Hydrochloric Acid and Saltcake.* By Dr. A. C. Cumming. Pp. xv+423. 31*s.* 6*d.* net. (London and Edinburgh: Gurney and Jackson, 1923.)

THE various treatises on different departments of applied chemistry which chemical literature owes to the genius and industry of the late Prof. Lunge are among the classics of chemical technology. They have passed through many editions in fairly quick succession, and their betterment and revision was the constant employment of their author's leisure, no pains being spared by him to make them an accurate and faithful reflex of the state of contemporary knowledge of the several subjects with which they were concerned. Prof. Lunge enjoyed many opportunities and facilities to this end. As professor of applied chemistry in the Zurich Polytechnic, one of the best equipped and most famous schools of chemical technology in the world, he was an acknowledged authority on many branches of manufacturing chemistry, and particularly on the special branches dealt with in the books under review. The manufacture of acids and alkali was in fact the chief chemical industry in which Dr. Lunge was employed during his sojourn in England and before his appointment to the distinguished position he occupied until his death. A brief account of his life and work appeared in NATURE of February 17, p. 228.

These treatises constitute, in the aggregate, a valuable literary property, and the publishers are well advised in seeking to maintain the reputation they have hitherto enjoyed as faithful and accurate accounts of the state of contemporary procedure in the special branches of chemical industry with which they deal, by entrusting their revision to competent authorities, and in issuing new editions at comparatively short intervals.

It might be thought that in the case of an industry so well established as that of the manufacture of alkali and of the industries which are so closely associated with it, the last word had been said in respect to processes and procedure. Such, however, is very far from being the case, as even a very superficial comparison of successive editions of these treatises will make manifest. The changes may not in all cases be fundamental or subversive, but they are more or less important as tending to efficiency and economy, and no account of the contemporary condition of the manufacture would be adequate without reference to them.

The general superintendence and editorship of the new editions of these manuals has been entrusted to the competent hands of Dr. A. C. Cumming, under whose direction they have been completely revised and rewritten. The volume on raw materials for the manufacture of sulphuric acid and of sulphur dioxide has been assigned to Mr. Wilfrid Wyld, who has been associated with important concerns in Yorkshire and elsewhere, and brings to his task the fruits of a large experience.

In a general preface prefixed to the several volumes Dr. Cumming has given a brief account of the history and development of the late Prof. Lunge's literary labours in connexion with applied chemistry, which is of interest as showing how the scope of these labours was gradually enlarged so that it became practically an encyclopedia of the many chemical industries. The first English edition of the volume on sulphuric acid appeared in 1879, and the last edition in 1913. This was followed in 1917 by a supplementary volume on sulphuric and nitric acids. This was the last of Lunge's contributions to this special field of chemical technology.

The book under review shows no very striking features in the way of new developments. As regards raw materials, the most important change is the revolution in the production of commercial sulphur effected by the Frasch process. This remarkable process is one of the most notable chemical engineering triumphs of the present century. In 1869 an enormous deposit of sulphur was discovered in Louisiana in the course of well-sinking in connexion with petroleum, but all attempts to work this deposit commercially failed until the genius of Herman Frasch devised the method associated with his name. Space will not allow of any detailed description of the process. Briefly, the method consists in sending down a sufficiency of superheated water and thus melting out the sulphur, which liquefies at about 116°, from the pockets in the limestone and beds of gypsum in which it occurs. The molten sulphur is then forced to the surface by means of compressed air, and of course consolidates as it cools. The book contains a fairly full account of this process, which is now worked on a very considerable scale, not only in Louisiana but also in Texas, where similar sulphur deposits have been found to occur. It has rendered America independent of all outside sources of sulphur supply, and for a time seriously threatened the existence of the Sicilian industry, of which it has destroyed the monopoly.

Mr. Wyld's account of the history of the process and of its successive developments leaves nothing to be desired in point of accuracy and completeness. It forms indeed a most interesting section of the chapter devoted to the exploitation of the natural deposits of sulphur which occur in various parts of the world.

The book, of course, deals with a great variety of processes for obtaining sulphur: from raw ores; from spent oxide in the manufacture of coal-gas; from pyrites; from sulphur dioxide, as from smeltery fumes; from sulphuretted hydrogen and sulphites and sulphides and from sulphates of the alkaline earths. These last-named processes became of the utmost importance to Germany during the War, owing to her inability to import sulphur or any considerable supply of pyrites. History affords many instances where a nation or manufacturing community under the stress of necessity, often occasioned by war, has been compelled to adopt new methods or to modify existing ones, and such modifications have frequently taken a permanent place in industry. What, however, is to be the ultimate fate of the processes which Germany was compelled to adopt remains to be determined. Certain of them have been found to be economically unsound when compared with pre-War methods, and have already been given up, but their story is interesting as a chapter in industrial progress and as showing what knowledge, skill, resourcefulness, energy, and application will achieve in overcoming obstacles which at first sight seemed well-nigh insuperable.

In an industry such as that described in this book analytical control is frequently of the utmost importance, but it is too often neglected, or only inadequately carried out, owing, in many cases, to the want of suitable methods or to the time required to make the results available to the management.

A commendable feature in the book is the space allotted to descriptions of the most suitable analytical methods at the disposal of the works chemist. The treatise in this respect becomes a veritable *vade mecum*, and should be indispensable to every well-ordered factory. The improvement of analytical processes applicable to the conditions of chemical works was a constant problem with the late director of the chemical department of the Zurich Polytechnic, and certain of the methods described in this book are the outcome of investigations made by him in conjunction with his senior pupils.

The various forms of pyrites, brimstone, and spent oxide are the usual sources of sulphur dioxide, mainly as an "intermediate" in the manufacture of sulphuric acid. For small-scale operations sulphur dioxide is made by heating charcoal or sulphur with sulphuric acid, usually of 74 per cent. SO_3 or 165° Tw. As the gas is easily liquefied, the temperature of a mixture of snow or powdered ice and salt being sufficient to effect its condensation, it may be preserved as a liquid in ordinary soda-water syphons, whence the liquid or the gas may be liberated as desired. This section of the book contains a full account of the physical and chemical properties of this compound, the modes of its detection and estimation, and of its employment in the manufacture of wood pulp and as a disinfecting and antiseptic agent and also as a bleaching agent, especially for wool, silk, straw, etc., and to a limited extent in wine-making in the form of meta bisulphite. Other sulphur compounds of which full and accurate accounts are given are sulphur trioxide and the various nitrogen-sulphur compounds. Indeed, the chemical history of the various sulphur compounds, so far as these have any relation to sulphuric acid and its manufacture, may be said to be accurate and complete.

As regards the actual manufacture of sulphuric acid, a comparison with the accounts given in the earlier editions shows what the influence of the War has been on the production of this important chemical. Pre-War plant was found to be utterly inadequate to meet the demand for this acid, as incidentally required in the manufacture of munitions, and, as is well known, it was necessary to make special arrangements to this end. Some account is given of the means installed at Queen's Ferry and other places. The section on burners for sulphur and on the plant needed in connexion with the use of pyrites has been carefully revised and brought up-to-date, and constitutes one of the most valuable sections of the work.

The volume on the manufacture of hydrochloric acid and salt-cake exhibits, perhaps in a more striking manner, the changes, almost revolutionary in character, which have overtaken this special branch of the alkali manufacture. The Hargreaves' process is no longer in operation in this country. Pan and furnace methods are still worked, but with the gradual disappearance of the Leblanc process it may be anticipated they will give way to one or other of the more modern processes described in this volume.

As the editor points out, the manufacture of hydrochloric acid is no longer necessarily connected with the manufacture of salt-cake, and fuller treatment has therefore been given to its manufacture from chlorine and to other modern developments.

The revised work is a most valuable addition to the literature of one of our staple industries, and the editor is to be congratulated on the care and thoroughness with which he has completed his task.

T. E. THORPE.

National Eugenics.

(1) *Eugenical Sterilisation in the United States.* By Dr. H. H. Laughlin. Pp. xxiii + 502. (Chicago: Psychopathic Laboratory of the Municipal Court of Chicago, 1922.) n.p.

(2) *Eugénique et sélection.* Par E. Apert, L. Cuénot, Le Major Darwin, F. Houssay, L. March, G. Papillaut, Ed. Perrier, Ch. Richet, G. Schreiber. (Bibliothèque générale des Sciences sociales.) Pp. iii + 248. (Paris: F. Alcan, 1922.) 15 francs net.

"NATIONAL Eugenics is the study of those agencies under social control which may improve or impair the racial qualities of future generations." Galton thus linked the word "national" to eugenics. The problem in its fundamental biological aspects is in one sense the same for all nations, but to each nation it may present different sides and provoke different methods of attack, if indeed it is attacked at all. The experiences of one nation are, nevertheless, worthy of observation by all.

(1) From this point of view, the first part of Dr. Laughlin's book is of interest. This part consists of a detailed analysis, written from a lawyer's point of view, of the sterilisation laws enacted in the United States prior to January 1, 1922, with summaries of the extent to which they have been put into practice in different States and a full account of the litigation arising out of them. Fifteen States have had, and nine still have, sterilisation laws, some mandatory and some optional. The scope of these laws varies from State to State, but in no case extends beyond certain inmates of State, county, or municipal institutions. The consent of the relatives has in general been easily obtained. There is very great variation in the opinions quoted of the executive boards and superintendents, and consequently in the extent to which the laws have been put into practice.

From 1907 until January 1, 1921, 3233 operations in all were carried out under the laws, and of these 2558 occurred in California (1009 being due to a single institution). Nebraska comes next with 155 cases. In Wisconsin, Connecticut, and North Dakota the law is still being applied, but to a very limited extent. In Washington, where the object is purely punitive, only one case has so far occurred. In six of the fifteen States the law has been repealed or vetoed, and in three it has become a dead letter. In test cases, violation of the State or Federal constitution has been argued chiefly on the grounds of class legislation, cruel or unusual punishment, or denial of equal protection of the laws. In five States the courts have held the sterilisation laws unconstitutional, but the quoted opinion of various American legal experts differs more on their expediency than on their constitutionality. The history of the working of these laws indicates that, in the country as a whole, public opinion is not at present behind them.

As an exhaustive historical record and guide to existing practice in the United States this compilation will no doubt prove a useful book of reference for those practically concerned with sterilisation in the legislative, legal, and administrative fields. As a contribution to the scientific discussion of the social and biological aspects of the problem it has less weight. The section on eugenical diagnosis is intended "to serve the legislator in his efforts to weigh the matter in its entirety." It is not easy to see, however, that this purpose can be achieved by the somewhat crude and uncritical summary offered of Mendelian theory and its application. The student will find the book overloaded with detail (incidentally there are discrepancies between text and table in the indentification numbers of individuals in the case pedigrees), but it contains a great deal of information, not easily accessible hitherto, of which the eugenist should not be ignorant.

(2) "Eugénique et sélection" is a collection of papers, most of which were delivered as lectures during 1920–21 at the meetings of the "Société française d'Eugénique," and are devoted mainly to a discussion of the consequences of the War in France from a eugenical point of view. It includes an earlier paper by the late vice-president of the Society, Frederic Houssay, in which, starting from a series of experiments on six generations of hens, he argues that there is a degeneracy of those in easy circumstances due to the abuse of food, each generation poisoning the next through toxic excretions into the germ cells.

Dr. Apert deals with the effect of the War on the health of the French nation. The two chief qualitative results he finds are an increased tendency to tuberculosis and the expectation of a series of infantile generations of lessened resistance to disease. To these he adds alcoholism and syphilis as active menaces to the French race. M. Lucien March treats the question from a quantitative aspect. He estimates the total loss of population to France (including the deficit of births) directly due to the War as 3,000,000 people. He examines the size of family in various classes, and gives as the three fundamental factors on which the birth-rate depends: (1) the cost of the child before he is self-supporting; (2) the chance the child has of maintaining himself in at least as good circumstances as his parents; and (3) the opinion that the parents hold of (1) and (2). He outlines the various steps taken in France to encourage natality, among which may be noted the existence of more than 70 employers' associations which give benefits for each child of an employee, but safeguard at the same time against preferential employment of single men by basing each employer's contribution on the total salaries paid by him. None of these measures are contrary to eugenical principles; they are, however, aimed directly at quantity instead of quality. From the psycho-social aspect and a consideration of the statistics of insanity and suicide Dr. Papillaut finds in the War confirmatory evidence of the predominant effect of heredity over environment. War effect on marriages is discussed by Dr. G. Schreiber. He regards the mixed marriages of French women with men of other Allied nationalities as a probable benefit to the French nation. He urges the establishment of a medical examination before marriage that shall be compulsory but carry no legal sanction.

The volume closes with an address on some zoological aspects of eugenics delivered by M. Lucien Cuénot at the second National Congress of Eugenics in 1921. Starting from the Mendelian conception of unit factors susceptible of mutations which appear as somatic changes, he discusses the position of Mendelists with reference to the heredity of acquired characters and the origin of adaptations. On the first question the author retains an open mind in the light of Guyer and Smith's experiments on the inheritance of acquired eye defect in rabbits. He puts the case well for preadaptation—*i.e.* the surroundings as a consequence of the structures with which the animal is born and not *vice versa*—and reviews the difficulties of interpretation of the mechanical perfection of certain structures in relation to their apparently small utility. Such difficulties lead him to feel that there is something wanting in the conception of evolution, some general law that has still to be discovered.

A collection such as this, which treats the subject from so many points of view, can do no more than touch the surface, but it is well adapted to fulfil its aim of giving the French-speaking public an idea of the object and extent of the science of eugenics as defined by Galton.

The Animal Parasites of Man.

Animal Parasites and Human Disease. By Dr. Asa C. Chandler. Second edition, revised. Pp. xiii + 572. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1922.) *22s.* net.

IT is unfortunate that animal parasitology, the youngest branch of preventive medicine, is still regarded by many people as a field of knowledge that is of little moment outside tropical and subtropical regions. Everybody acknowledges the direct connexion with man's welfare of the parasites dealt with in the sister science of bacteriology; but the parasitic protozoa, helminths and arthropods, which are responsible for so much human suffering, are scarcely thought of by the general public. Indeed, even the average physician of temperate climates seems to be satisfied to have quite a superficial knowledge of this branch of his profession; yet these parasites, which are concerned with the most varied diseases and morbid conditions, have been found to be widespread and in abundance, wherever they have been looked for. There are many popular books on the animal parasites of economic importance, but remarkably few on those which affect human health. It is admittedly very difficult to write an attractive book, in popular language, on any scientific subject, and when the book deals with such objects as tapeworms, fleas, and lice, the general reader is apt to put it aside with a faint feeling of disgust. But among these and other such despised creatures are many the life histories of which are of much interest, and on account of the practical importance of their relations to man, they should claim the attention of all.

Dr. Chandler describes his book as a compilation, but it is more than that: the subject is presented in a fresh and interesting manner, and the book shows evidence of much care and skill in the selection of its contents. The information given has been brought thoroughly up-to-date, and all recent work of any importance is referred to. A sufficient account is given of the spirochætes, which the author considers to be "on the vague unsettled border-line between bacteria and protozoa." Many, perhaps, would be inclined to adopt a more critical attitude towards the phenomenon of "granule shedding" in these organisms. The subject of the prevention of syphilis is discussed in a broad and logical spirit. The leishmania bodies, trypanosomes, intestinal flagellates, and amœbæ are well described, and there are short accounts of the diseases to which they give rise. The author seems to accept without demur the parasite recently described by Kofoid and Swezy, and named by them *Councilmania lafleuri*. The parasitology of malaria is adequately dealt with, and the Rickettsia organisms are alluded to. The life history of the liver fluke is told at length, and illustrations and descriptions are given of the other trematodes which occur as human parasites. The "worms" are all figured, and the salient points of their bionomics mentioned. Ten pages are devoted to *Trichinella spiralis*, and about as many to the various species of Filaria. The rest of the book, about two hundred pages, is concerned with the arthropoda. The entomological section is particularly good, and contains an excellent account of the habits and distribution of those insects which are harmful to man.

Throughout the book, adequate reference is made to the diseases caused by animal parasites, and to the methods employed for controlling the latter. With a few exceptions, the illustrations are good, and they possess the commendable feature that, where the organism is not drawn of the actual size, the magnification used is always indicated.

It is to be hoped that this excellent book will help to arouse a more general interest in a subject with which all are personally concerned. Although it is written in a popular style, the book is always accurate; any one who reads it carefully will acquire the foundation of a good general knowledge of the animal parasites of man, and, if he wishes to pursue the subject further, he will find that he has nothing to unlearn.

H. J. WALTON.

Our Bookshelf.

Spezieller Kanon der zentralen Sonnen- und Mondfinsternisse, welche innerhalb des Zeitraums von 600 *bis* 1800 *N. Chr. in Europa sichtbar waren.* Von J. Fr. Schroeter. Pp. xxiv+305+cl Tafeln. (Kristiania: Jacob Dybwad, 1923.)

IN this volume Schroeter continues Ginzel's "Spezieller Kanon der Sonnen- und Mondfinsternisse" (1899), which contained all eclipses visible in an area between 10° W. and 50° E. of Greenwich, and between 30° and 50° N. latitude, from 900 B.C. to A.D. 600. Schroeter's scope is somewhat different. He gives all central eclipses of the sun and all total eclipses of the moon visible in Europe between A.D. 600 and 1800. For partial eclipses of the moon between those dates it is still necessary to turn to Oppolzer. It will be observed that the area covered by Schroeter differs widely from that covered by Ginzel, and results from the substitution of a European for a Mediterranean civilisation. One result of this selection is that the present volume is of little use for the study of the numerous eclipses recorded in the history of non-European countries. Perhaps some day each continent will have its own equivalent to Schroeter.

The elements of eclipses used in this volume are based on the same constants and computed by the same formulæ as those determined by Ginzel and used in his "Spezieller Kanon," but the errors attaching to the results are far less at the dates for which these tables are constructed than for the distant dates with which Ginzel deals. One advantage of Schroeter's volume over Ginzel's is that, while an exact computation from Ginzel's elements can only be made by reference to the formulæ contained in Oppolzer's "Canon der Finsternisse," Schroeter prints these formulæ in his introduction. Another difference is that where Ginzel contents himself with computing the northern and southern limits of the total or annular phase of a solar eclipse, Schroeter computes also the curves of nine digits magnitude. Again, while Ginzel has one large-scale map showing all the zones of total and annular eclipses for each century, Schroeter, though limiting himself to a smaller scale, has a separate map for each eclipse. There is, however, nothing in Schroeter to correspond to the detailed discussion of each historical eclipse which is one of the most valuable features of Ginzel's work.

This work is likely to be of more use for historical than for astronomical studies. Probably it will be used mainly by those astronomers who may be called upon to assist students of history.

Modern Gas Producers. By N. E. Rambush. Pp. xix+545. (London: Benn Bros., Ltd., 1923.) 55*s.* net.

WE have nothing but commendation for this treatise on modern gas producers. It is a finely conceived work admirably executed. The author is one of the few equipped with theoretical knowledge of the thermal processes involved in producer gas manufacture, and with the extensive acquaintance with technological aspects of the matter required for an adequate treatment of the subject. Of this, the work before us is sufficient witness. Four sections devoted respectively to (1) the theory of the formation of producer gas, (2) types of gas producers, (3) control and operating principles of producer gas plants, and (4) the utilisation of producer gas, are comprised in the book. The theory of the subject is developed in an extremely clear manner. We think the author has succeeded in his declared endeavour to describe plants and types of producers quite impartially. A rather careful reading of the work has left us quite undecided as to what plants the author has been personally connected with in a professional capacity. This is eminently desirable in a work of this nature, and in marked contrast to what we have found in at least one volume of the present series of publications. Specific features of design commonly employed in practice and of a number of special designs are set out in considerable detail. This section might easily have degenerated, as has happened in too many cases recently, into a highly priced trade circular. It has not done so, but is extremely readable and informative, and contains much valuable data relating to actual trials of the various plants. The third section is commendably brief, as fuller particulars of the testing of fuel and gas are contained in another volume of the same series. Typical applications of producer gas in the gas engine, gas turbine, furnaces, etc., and the relative efficiencies in use of various grades of gas, are briefly treated in the last section.

The work is characterised by a number of extremely valuable tables and graphs facilitating calculation. There are altogether 356 drawings and illustrations, all beautifully executed and reproduced. An adequate index is provided. We think the high price of the volume justifiable, and prophesy an assured premier position for the work in the literature of producer gas technology.

J. S. G. T.

Department of Scientific and Industrial Research. Report of the Fuel Research Board for the Years 1922, 1923. First Section: The Production of Air-dried Peat. Pp. vii+146. (London: H.M. Stationery Office, 1923.) 5*s.* net.

MECHANICAL methods of winning peat in operation in Europe and Canada are dealt with in this report, in which are discussed the difficulties encountered in winning the air-dried fuel, and possible schemes for winning it on a very large scale. It describes also the investigations on the winning and the utilisation of peat undertaken by the Fuel Research Board during the past four or five years. These investigations were the preparation of air-dried machine peat in an Irish bog, but by well-known Continental methods and on a very small scale, together with the establishment of the facts, long known abroad, that machine peat dries more uniformly than slane-cut peat, and has a higher value than slane-cut peat of the same calorific power.

The report is disappointing inasmuch as it shows that the Fuel Research Board has not made any serious attempt to grapple with the problems of the winning and the utilisation of peat. On the other hand, it is valuable since it shows that several attempts to solve these problems are being made in Germany, Sweden, Russia, and Canada. Prof. Purcell's detailed and critical descriptions of the peat industries of northern Germany, Sweden, and Canada are interesting and instructive. One would have expected, however, that the Fuel Research Board's contribution to the solution of these problems during the past four or five years would have been considerably more than a full description of what other and poorer countries are doing in regard to these important matters. HUGH RYAN.

El Arte de los Metales (*Metallurgy*). Translated from the Spanish of Alvaro Alonzo Barba, by Ross E. Douglass and E. P. Mathewson. Pp. ix+288. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1923.) 17*s.* 6*d.* net.

THE earliest known work on American metallurgy was written by Alvaro Alonzo Barba, a priest of Potosi in Bolivia, and was published in Spain in 1640 and several times reprinted. This book, of great historical interest, has now been fully translated by two American metallurgists, and forms an important technological document. The most valuable feature of the work is its detailed description of the methods of extracting silver from its ores practised in Bolivia, a region in which metallurgical skill had at that time attained to a very high level. Amalgamation and the processes connected with it are here described minutely, and in a straightforward fashion, with simple diagrams. Barba was not a profound thinker, and accepted the current superstitions regarding ores and minerals without question, comparing in this respect very unfavourably with his great predecessor Agricola; but his shrewdness in practical matters and his close acquaintance with the work of smelting and extraction on a large scale are evident throughout. The translation, except for a few explanations of technical terms, inserted in brackets, is not annotated, so that the student will do well to read it in conjunction with Hoover's remarkable translation of Agricola, with its abundant historical notes. C. H. D.

An Introduction to Stratigraphy (*British Isles*). By Dr. L. D. Stamp. Pp. xv+368. (London: T. Murby and Co., 1923.) 10*s.* net.

THIS is a distinctly original work that will be of service to very many students who are unable to follow current literature as it appears. Dr. Stamp brings together, with good references, results recently obtained by others, but adds to them by his personal knowledge and his methods of appreciation. Sections showing the mode of deposition of various series, and sketch-maps of their distribution, give unusual interest to what might have been a mere description of the part played by each formation in the structure of the British Isles. As examples, we may take the general map and the small local section (pp. 146 and 147) dealing with the Millstone Grit, and the suggestive map (p. 170) of Britain in the Permian period, with its stream-notched uplands supplying material to the basins in the midlands and the south. Not content, the author gives us an enlarged detail of the Cornubian area on p. 175. Dr. Stamp (p. 241) is not so bold as Mr. E. Greenly in carrying his Cretaceous strata across the peneplane of Snowdonia. He writes throughout, in spite of very concise limits, as if he were actually viewing from an aeroplane the geographic features of the past.

G. A. J. C.

Primitive Tider i Norge: En oversigt over stenalderen. Av Haakon Shetelig. Pp. iv+380. (Bergen: John Griegs Forlag, 1922.) n.p.

DR. SHETELIG, in his introduction, points out that in few countries in Europe does written history begin at so late a date as in Norway. This gives to the study of prehistoric antiquities in that country a position of peculiar importance. For archæologists generally the prehistory of the area of which Norway forms a part is also of particular interest, especially in its earlier stages, in view of its relation to that of the rest of Europe; it is there that we find the evidence for the earliest stages of neolithic culture. On both accounts, therefore, Dr. Shetelig's study of the Stone Age in Norway is welcome. For students outside his own country its value will lie largely in the author's survey of the latest views of Norwegian men of science on Scandinavian archæology and the relations of Norway in the Stone Age to the rest of this area. From this point of view his chapters on the first appearance of man in Norway, the transition to the New Stone Age, and the kitchen-middens are particularly worthy of note, as also is his account of Stone Age art, the trade in amber, and the use of jade. The book is fully and admirably illustrated.

How to Paint Permanent Pictures. By Prof. M. Toch. Pp. 105. (London: Scott, Greenwood and Son; New York: D. Van Nostrand and Co., 1922.) 7*s.* 6*d.* net.

THE reviewer has often wondered, when looking at paintings of great merit which are gradually fading away or cracking in pieces, why artists do not spend a little time in learning something about their materials. In many cases they are probably at the mercy of the dealers. It would seem desirable, therefore, to direct attention to this small book by Dr. Toch, which deals with the properties of pigments simply yet scientifically, and should be valuable to all who paint pictures. In it are described those colours which are permanent and those which may be expected to fade away more or less completely with lapse of time. Varnishes are also discussed.

Letters to the Editor.

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

The Inheritance of Acquired Characters in Alytes.

FOR those who are not concerned with the details of this debate I suppose that the critical sentence in Dr. Kammerer's letter (NATURE, August 18) is that in which he expresses himself as follows: "I willingly admit that the traditional explanation of the pads, namely, that they are produced by friction with the skin of the female, may possibly be a fable," adding references to passages in which he had already discussed alternative hypotheses. But those alternatives were ultimately rejected, and his final judgment was that until the assumption that the pads arise through functional adaptation can be replaced by a better, it remains the only acceptable account.[1] Remarking that the alleged nuptial pads may possibly be due directly to life in water and not an adaptative response, he now tells us that the relevance of his observation to the theory of heredity is in either alternative the same But is it?

The heavy task of searching for evidence of hereditary transmission of acquired characters has clearly been undertaken in the single hope, forlorn indeed, but undying, that the difficulty created by the existence of the *adaptative* mechanisms might be removed. They constitute a very grave difficulty in all theories of evolution. Various evidence, mostly ambiguous but as a whole significant, does suggest that in special cases, by violent treatments, the germ-cells of animals may be affected, more or less injuriously, and that the consequences may persist at least for some generations; but that does not help us with the problem of adaptation. Dr. Kammerer's admission would relegate the Alytes pads to that class of phenomena. Had this been all that was claimed, I should have felt some interest in the matter, but less.

The significance of the story is now reduced. In 1909 we were told that nuptial callosities appeared on the *thumbs* of treated males, and that all the males of the "F_4" generation had them. The claim that this was a true adaptation was made without any qualification whatever. This led to my request (made privately in 1910, published in 1913) that a specimen should be produced. In 1919 we hear for the first time that the swellings appear in various other regions of the arms. When at length a specimen is produced, I find it mounted to display a dark thickening on the palm of the hand, a place which, unless I am mistaken, had not previously been specified. That this was the structure to which Dr. Kammerer particularly wished to direct our attention appears also from the fact that the new photograph sent to Prof. MacBride, which I have not had the privilege of inspecting, was made from it. So far as I am aware, this is the only specimen ever exhibited publicly.

Dr. Kammerer complains that I did not at the Linnean meeting produce "a single one of the many objections" alleged in my letter of June 2. His memory is at fault. My chief objection was the position of the pad on the palm. Any one who attended the meeting will know that I directed very prominent attention to this feature. To make my objection clear and conspicuous I asked in German: "*Das Männchen umarmt sein Weibchen—so*—[turning the backs of my hands inwards]—*nicht?*" To which Dr. Kammerer as I thought nodded assent. No one can have forgotten that the next speaker took me to task for this, saying by a slip, induced I suppose by what he had seen of the specimen, that "of course" the common toad clasps the female with the palms towards her.

Why Dr. Kammerer should think that in writing of his diagrams I had in mind a book of Plate's (which I hear of for the first time), I cannot imagine; for I added the exact references to his own paper of 1909, Figs. 26 and 26*a*. The pictures which I threw on the screen, illustrating the fantastic story of Mendelian segregation in respect of the modified habits, will also be found in his paper 12 *Flugschr. d. Deut. Ges. f. Zuchtungskunde*, 1910, and again in *Natur*, Munich, December 12, 1909, papers to which all readers desiring to see the prodigious scope of the original claims should refer. A more detailed though unillustrated account appears in *Mendel Festschr.*, Brünn, 1911.

I do not propose to rebut the minor allegations made by Dr. Kammerer. Several of these would not have been made had he seen my letter in NATURE of July 3, 1919. The answers to the rest will be evident to those who have followed the discussion.

The question remains, what is the real nature of the swellings in the animal exhibited? That on the palm did not look like a nuptial pad. What there may have been on the back of the hand I do not know. I made no statement about it, though Dr. Kammerer says I did. I might no doubt have asked to see the back, but I had no reason to suppose there was anything more to see. The palmar mark was what we were shown for our conviction. This looked so unlike what I remembered of real *Brunftschwielen* that I did ask in the discussion, "*Wie wissen Sie, dass sie Brunftschwielen sind?*" I knew our frog and toad very well, and, of course, Lataste's drawings of sections, but it was some years since I had looked at other species. I thought that perhaps, where the development is slight, as in *Rana agilis*, the external appearances might be less unlike what I had seen in the Alytes, but they are not. When with that specimen fresh in mind I examined a series of nuptial pads in various Batrachia I realised still more vividly how widely the structure in the Alytes differed from the real thing. In my letter, therefore, I laid stress on the dissimilarity.

Dr. Kammerer writes that his specimen was examined out of the glass by Sir Sidney Harmer and Mr. E. G. Boulenger, but we are not told whether they are among the "dozens" now convinced. Mr. Perkins states that "the epidermal spines are very obvious in the intact specimen." He is the only independent witness, of those whose opinions have reached me, who claims to have seen anything so definite.

I have a strong curiosity to see this Alytes again. Dr. Kammerer challenges me to supply him with apparatus for the purpose of photographing it. I will make a different offer. For the opportunity of examining it at leisure in the British Museum, where comparative series are available, or if preferred in Prof. MacBride's laboratory, I am willing to pay 25*l*. either to the Versuchsanstalt or to other appropriate authority. Plenty of responsible people travel between Vienna and London, and there should be no difficulty in arranging for safe conveyance.

W. BATESON.

The Manor House, Merton, S.W.20,
August 26.

[1] 1919, p. 353: "Bevor also unsere Annahme, die Schwielenbildung geschehe durch funktionelle Anpassung, durch keine bessere ersetzt werden kann, bleibt sie die einzig akzeptable."

A Possible Origin of the Nebular Lines.

THE hypothesis that the lines of unknown origin in the spectra of nebulæ are due to the atom of some hitherto undiscovered element ("nebulium") is not the only one that may be advanced. The recently developed quantum theory of band spectra makes it at least possible that these lines could have their origin in a *molecule* with small moment of inertia composed of atoms of those elements which are known to exist in nebulæ. It is proposed in this letter to show that the existing astronomical evidence is not in contradiction to this alternative hypothesis, and also to indulge in some speculation as to the nature of such a molecule.

The Nebular Spectrum.—The absence of band heads in the nebular spectrum does not necessarily preclude the possibility of a molecular origin. In a band spectrum the individual lines of a single band may be arranged in a Deslandres formula,

$$\nu = A \pm 2Bm + Cm^2,$$

where m takes the successive values 1, 2, 3, etc., and the line corresponding to $m=0$ is missing. The lines, therefore, arrange themselves in a positive (R) and negative (S) branch on either side of the missing line $m=0$; the band head is due to the overlaying of one or other branch on itself, depending upon the sign of C, and occurs in general only for large values of m. To a first approximation, however, the lines in either branch are equally spaced with a separation equal to 2B, where on the quantum theory of band spectra (Sommerfeld, "Atombau," chap. 7) B is inversely proportional to the moment of inertia of the molecule. The smaller this moment of inertia the more widely spaced will be the lines, and from the Boltzmann probability factor the fewer there will be of them. Accordingly, if the hypothetical molecular carrier of the nebular spectrum has a small moment of inertia, the resultant spectrum will consist of isolated lines with no band heads—in general agreement with that observed.

Slightly more positive evidence can be gained from a closer consideration of the nebular spectrum. The important work of Wright (Lick Observatory Publications, vol. 13) has shown that the nebulæ may be arranged in a series from low excitation (strong H, no He lines) through medium to high excitation (H and strong He^+ lines). At the top of the accompanying diagram (Fig. 1) are shown the positions (on a wave number scale) and intensities, as given by Wright, of the nebular lines of unknown origin for B.D. +30° 3639 (low excitation) and N.G.C. 7027 (high excitation). For convenience of reference the high excitation spectrum is also repeated at the bottom of the diagram; the dotted lines shown in this spectrum are suspected nebular lines which occur in nebulæ of medium excitation, but not in N.G.C. 7027.

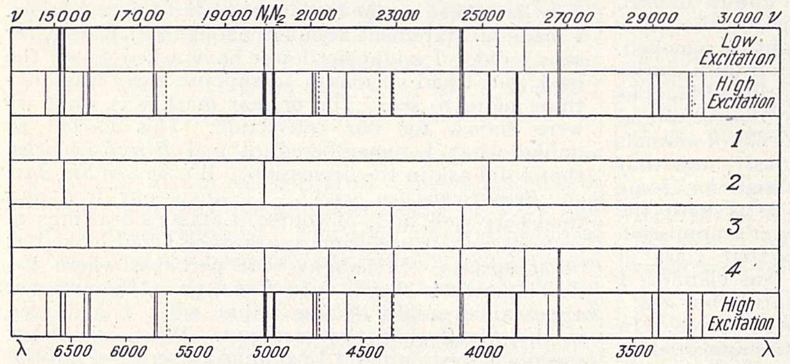

FIG. 1.

The change in intensity and in the number of the nebular lines with increase in excitation is very striking, and this fact may be used in an attempt to select band lines in the spectrum. For the intensity of a line depends primarily on the number of molecules which are in the particular quantum state m, and, according to the Maxwellian distribution of rotational velocities, with increase in excitation the maximum of rotational speeds will shift to the higher quantum numbers. Thus, for low excitation, lines corresponding to $m=\pm 1$ will be strong, but with increase in excitation the lines $m=\pm 2$, ± 3 will gain at the expense of $m=\pm 1$. Using this as a guide, a number of possible band groupings have been suspected in the nebular spectrum, and these are shown as Nos. 1, 2, 3, 4, in Fig. 1. A few words of comment may be made on these.

Nos. 1, 2.—These two groupings comprise the six strongest lines in the spectrum, including N_1, N_2, 3967, 3868. It will be noted how the maximum of intensity shifts from the red lines to the violet with increase in excitation. It has been assumed that each grouping is a positive (R) branch of a single band, and the constants of the Deslandres formula have been computed.

$$\text{(No. 1)}\quad \nu = 10915{\cdot}9 + 3916{\cdot}3m + 352{\cdot}9m^2,$$
$$\text{(No. 2)}\quad \nu = 11098{\cdot}4 + 3903{\cdot}6m + 265{\cdot}4m^2.$$

The close similarity of the constants B for each group suggests that 1 and 2 are two positive branches of a single band with zero line far out in the infra red. Curtis has found in the He_2 spectrum (Proc. Roy. Soc. A, 101, 38, 1922), a band (λ5730) with two positive branches with slightly different (12 wave numbers) values for the zero lines.

No. 3.—This suspected band contains four lines with a dubious fifth, and consists of a positive (R) and negative (S) branch with the line $m=0$ as usual missing. Using the lines with wave numbers S (1) 17679, R (1) 21219·2 and R (2) 22912·50 to compute constants, the following formula is reached:

$$\nu = 19474{\cdot}7 \pm 1770{\cdot}1m - 25{\cdot}6m^2.$$

The computed wave number of S (2) is 15832, and there is an observed line at 15836 (±3), which may be considered satisfactory agreement. The computed wave length of R (3) is 24555, and there is a strong line at 24571·5 (±0·1). The agreement is not satisfactory, the intensity relations are not satisfactory, and it is accordingly very doubtful whether this line belongs to the group. The remaining four, however, make a satisfactory group, and it will be noted that while the lines R(1), S(1) make their appearance in nebulæ of medium excitation, the intensity is transferred to R(2), S(2) in the nebula of high excitation.

No. 4.—This suspected band contains eight lines, which may be divided into a negative (S), a positive (R), and a zero (Q) branch. The designations, wave lengths, and wave numbers are given in the accompanying table. The lines marked with asterisks were used in computing the constants for the R and S branches, namely,

$$\nu = 27586{\cdot}1 \pm 1560{\cdot}6m + 7{\cdot}4m^2;$$

from this was computed in the usual way the formula for the Q branch, namely,

$$\nu = 26805{\cdot}8 + 7{\cdot}4m^2.$$

The agreement between the observed and computed values can be seen from the table below. It is sufficiently close to suggest, in view of the approximate character of the band formula used, that there may be some reality in this grouping. As usual the intensity is transferred from the lines with low quantum numbers to those with high increase in excitation. It will be noted that the line N_1 is used in this grouping as well as in No. 2, and the suggestion is that this line is a close double of a strong and weak component, the latter of which belongs to the present group.

Designation.	Wave Length.	Wave No. (comp.).	Wave No. (obs.).	
S(5)	5006·84	19967·13*	19967·13	±0·04
S(4)	4658·2	21461·5*	21461·5	0·5
S(3)	4353	22964·6	22966	5·0
S(2)	4076·2	24494·4	24525·61	0·1
S(1)	3840·2	26032·9*	26032·9	0·7
Q(1)	3728·91	26813·2	26809·87	0·2
Q(2)	3726·16	26835·3	26829·65	0·3
R(1)	3426·2	29154·1	29178·5	±2·0

To summarise, of 34 lines in the nebular spectrum, 17, including the strongest, have been arranged in suspected band groups. Without additional evidence, however, no conclusion can be safely drawn as to the reality of these groups. While the numerical agreements are not unsatisfactory, it is far from impossible that such coincidences are fortuitous. Confirmation would be lent to this scheme if new lines could be found which would fall into one or other of the above bands; exposures of nebular spectra have been made here of as long as twenty hours without, however, detecting any new lines. In the meantime, then, until further evidence is forthcoming, the reality of the above groups must remain in doubt, and the only conclusion that may be safely drawn is that there is no inherent difficulty in supposing the nebular spectrum to have its origin in a molecular carrier.

Nature of the Hypothetical Molecule.—As the general appearance of the spectrum and the separation of the suspected band lines suggest, the moment of inertia of the hypothetical molecule must be small (of the order of 2×10^{-42} gm. cm.^{2}). So small a moment of inertia clearly suggests that the atoms which constitute the molecule must be of small mass. Of the elements hydrogen, helium, carbon, and nitrogen known to exist in nebulæ, only atoms of the first two are, therefore, likely to form the hypothetical molecule. The spectra of the H_2 and He_2 molecules are already known, and there is no similarity between either of these spectra on one hand and the nebular spectrum on the other. As a working hypothesis the suggestion may therefore be made that the nebular spectrum has its origin in a H He molecule with a moment of inertia of the order of 2×10^{-42} gm. cm.^{2}, and a resultant separation of the H and He nuclei of about $0·1 \times 10^{-8}$ cm. In view of the known chemical activity of atomic hydrogen and also of the existence of molecular helium, it is not improbable that such molecules must occasionally be formed. In fact, Aston ("Isotopes," p. 99) has suspected their existence in his positive ray experiments.

Probably the chief merit in the foregoing discussion is that it furnishes a suggestive working hypothesis for finding the nebular lines in the laboratory. The problem becomes one, not of finding new elements—a difficult matter—but of examining the spectrum of a molecule which is known to exist. While our knowledge of physical conditions in the nebulæ is still obscure, yet it may serve as a guide to experimental investigation. Clearly atomic hydrogen and helium must be present in a highly rarefied condition and presumably at low temperatures; such a condition can be duplicated probably by the introduction of some helium in the centre of a long Wood vacuum tube where atomic hydrogen is known to exist in abundant quantities. Not only must the conditions be right for the formation of the molecule, but once formed it must be excited to radiation; for a nebular absorption spectrum is not known to exist, and hence the normal hypothetical molecule must radiate in the far ultra-violet. Such difficult problems of laboratory technique must be left to others; an attempt, however, will be made here to secure further astronomical evidence on the reality or otherwise of the suspected bands.

H. H. PLASKETT.

Dominion Astrophysical Observatory,
Victoria, August 4.

Dutch Pendulum Observations in Submarines.

THREE submarines of the Dutch Royal Navy with the mother-ship *Pelikaan* are about to sail for Java. At the request of the Dutch Geodetical Committee (Rijkscommissie voor Graadmeting en Waterpassing), his Excellency the Minister of Marine has allowed Dr. F. A. Vening Meinesz, engineer appointed to the Committee, to join one of the submarines for the purpose of making pendulum observations on board during the voyage.

For several years Dr. Vening Meinesz has been engaged in determining the intensity of gravity at 51 stations in the Netherlands. The difficulties caused by the extreme mobility of the soil in part of the country induced him to work out a method for the elimination of the resulting disturbances; this has been applied with complete success, as will be shown in a publication—in French—to appear shortly. It was hoped that the extended theory might be applied to pendulum observations on board an ocean steamer. A first trial, however, on a steamer of the Koninklijke Paketvaart Maatschappij from Ymuiden to Flushing failed through the very turbulent sea.

In the spring of this year, Dr. Vening Meinesz gave a short exposition of his theory at the Physical and Medical Congress at Maastricht. Prof. F. K. Th. van Itterson, director of the Government mines at Heerlen, suggested that the observations might be successfully carried out on board a submerged submarine, where the disturbances could be expected to be less than on the surface of the sea. His opinion was found to be correct at a trial on board a submarine at the Helder. Notwithstanding the fact that a heavy gale was blowing and the sea was very rough, the movements of the ship, submerged at a depth of 15 metres, were so trifling that the amplitude of the pendulums, which were hanging quietly at first, amounted to no more than 8′-12′ after a quarter of an hour.

A brief exposition of the theory as given by Dr. Vening Meinesz at the Congress at Maastricht and published in *de Ingenieur*, 1923, No. 18, may be of interest.

The influence of the horizontal and vertical movements of the ship may be eliminated by the use of two pairs of pendulums swinging together from the same support, the two pairs moving in two planes. In the Von Sterneck apparatus used by Dr. Vening Meinesz, these two planes are at right angles to each other. The movements of each pendulum are to be photographically recorded.

The equation of movement of a pendulum is

$$\frac{g}{l}\theta+\theta''+\mathrm{D}=0,$$

θ being the angle of inclination and l the length of the pendulum, D a term introduced by the disturbances.

Putting $$\frac{g}{l}=n^2$$

and introducing the complex variable

$$q=\theta-\frac{i}{n}\theta',$$

which may be represented by a vector, the projection of which on the real axis is the angle of inclination θ, the equation assumes the form

$$q'=inq+i\frac{\mathrm{D}}{n},$$

and after integration

$$q=(q_0+\Delta^t q)e^{int}, \quad . \quad . \quad . \quad . \quad (1)$$

where $$\Delta^t q=\frac{i}{n}\int_0^t \mathrm{D}e^{-int}dt.$$

If D = 0, the constant vector q_0 is rotating with a constant velocity n.

If $\mathrm{D}\neq 0$, q varies by the quantity $\Delta^t q$ in the time t. The change which the term D causes in the amplitude, *i.e.* the length $q_0+\Delta^t q$, and in the period of the oscillation, *i.e.* the time in which $q_0+\Delta^t q$ describes the angle π, may be readily inferred from Fig. 1.

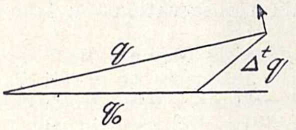

Fig. 1.

Equation (1) enables us to investigate the influence of the different causes of disturbance.

(1) *Horizontal Movements.*—If the acceleration of the horizontal movement is y'', we have $\mathrm{D}=y''/l$; using two pendulums with equal values for n and y'' and swinging in the same plane, the value of $\Delta^t q$ is the same for both; hence the difference of the oscillation vectors is constant. This constant vector may thus be considered as the oscillation vector of an undisturbed pendulum having the same period of oscillation. The angle of inclination of this hypothetical pendulum is equal to the difference between the angles of inclination of the two real pendulums.

Each pair of pendulums of the apparatus may thus be substituted by a hypothetical pendulum free from the disturbances caused by horizontal movements.

(2) *Vertical Movements.*—The influence of the vertical movements is less than that of the horizontal. On the other hand, it is impossible to eliminate it entirely. Since the vertical acceleration is indissolubly connected with the acceleration of gravity, it is obvious that elimination of the former would imply elimination of the latter.

From the following reasoning it appears, however, that we are able to eliminate the influence which depends on the phase of the pendulum, so that the result is only affected by the mean vertical acceleration. Expressing the vertical acceleration by y'', then we have $\mathrm{D}=(x''/l)\theta$. If we divide the equation of movement by q:

$$\frac{q'}{q}=in+\frac{in}{g}x''\frac{\theta}{q},$$

and represent the phase of the pendulum by ϕ,

$$\theta=a\cos\phi \quad\text{and}\quad q=ae^{i\phi},$$

where a is the amplitude; thus

$$\frac{\theta}{q}=\tfrac{1}{2}+\tfrac{1}{2}e^{-2i\phi},$$

the equation may be written:

$$\frac{q'}{q}=in+\frac{in}{2g}x''+\frac{in}{2g}x''e^{-2i\phi}.$$

Each hypothetical pendulum corresponding with a pair of pendulums of the apparatus gives a similar equation; the two may be distinguished one from the other by the suffixes 1 and 2. The following relation is easily derived:

$$in+\frac{in}{2g}x''=\frac{(q_1'/q')-(q_2'/q_2)e^{2i(\phi_2-\phi_1)}}{1-e^{2i(\phi_2-\phi_1)}}.$$

Passing to real quantities and putting the ratio of the amplitudes $a_2/a_1=p$, we get

$$n+\frac{n}{2g}x''=\frac{\phi_1'+\phi_2'}{2}-\frac{1}{2}\frac{p'}{p}\cot(\phi_2-\phi_1).$$

For the right-hand member of this equation the observations yield a mean value; the first term is the mean velocity of the phase.

For the computation of n it is necessary to know the mean value of x'' during the time between the observations; obviously we may take for this value

$$\frac{1}{t}(x'_{\text{end}}-x'_{\text{beginning}}).$$

If the beginning and the end of the observations coincide with the moments when the vertical velocity of the support may be supposed to be 0, the same is true for the mean value of x''. These moments cannot be accurately ascertained, but we may take the moments when the vertical movement changes its direction. The resulting error can be reduced *ad libitum* by extending the duration of the observations.

In this way the horizontal as well as the vertical movements of the support may be eliminated. The influence of the inclination of the support can also be taken into account. In order to obtain the required accuracy, however, it should not be allowed to exceed 1° in either direction.

J. J. A. Muller,
Member of the Dutch Geod. Comm.
Zeist, August 18.

Long-range Particles from Radium-active Deposit.

While studying the H-particles found by Sir Ernest Rutherford to be the first disintegration product of aluminium and some other atoms, under α-bombardment, we have developed a new method for obtaining strong and practically constant sources of such radiation. The method consists in enclosing dry radium emanation mixed with pure oxygen within thin-walled capillaries of hard (potassium) glass, lined with some 12 μ thickness of aluminium foil pressing well against the glass. As a small number of long-range particles were given off from the glass itself, we have also made use of capillaries drawn out from tubes of pure silica.

Some of the elements not previously investigated for H-particles have been examined in this manner by the scintillation method, the results proving that scandium, vanadium, cobalt, arsenic, and indium—the three first as oxides, the last two as metallic mirror and as chloride respectively—do not give off long-range particles (>30 cm. of air) to a greater number than 3 or 4 times $\mathrm{N}.10^{-8}$, where N is the number of α-particles from radium C discharged per second within the capillary. A very small number of such particles were actually observed with most of these substances, the scintillations being, however, too few for anything definite to be said at present regarding their origin.

Having regarded quartz as an ideal non-active substance to be used in these experiments, we were somewhat disappointed at finding, with a more thin-walled capillary than the others, a relatively large number of faint but distinct scintillations from the unlined part of the quartz, the rest of the capillary, lined with a thin coating of scandium oxide, giving no such scintillations. These scintillations practically disappeared when the total absorption was raised from 10 to 15 cm. by interposition of a mica filter. Similar results were afterwards obtained with other thin-walled capillaries; the absorption curve for the H-particles is being at present more accurately determined in this Institute.

Considering the high purity of the quartz, and the care taken to free the emanation from moisture and other hydrogen contaminations, we see no other way to explain this observation than by assuming silicon to give off H-particles of the maximal range just stated.

We have recently constructed a different emanation vessel in which the substances to be examined are spread in thin layers over copper foil of about 4 cm. absorbing power, forming the bottom of a narrow emanation trough, the emergent H-particles being counted from below with a scintilloscope. In this manner we have obtained fairly conclusive evidence that H-particles are also given off from the following elements:

Silicon, as element, approximate maximal range 18 cm. air.
Beryllium, as oxide, approximate maximal range 12 cm. air.
Magnesium, as oxide, approximate maximal range 13 cm. air.
Lithium, as carbonate, approximate maximal range 10 cm. air.

With lithium the results are less definite than with the others, mainly owing to the difficulty of excluding contamination with hydrogen compounds.

Blank experiments with only the bare copper foil (which had previously been bombarded with cathode rays in a vacuum to remove occluded gases) showed a much smaller number of H-particles. and, judging from the absorption curve, due to "neutral" H-particles. We are having the apparatus reconstructed so as to eliminate errors from this source.

A more detailed description of our experimental arrangement is being published shortly. The emanation capillaries will be used in this Institute also for studying atomic disintegration by the Wilson method.

Our results seem so far to indicate that the hydrogen nucleus is a more common constituent of the lighter atoms than one has hitherto been inclined to believe.

Gerhard Kirsch.
Hans Pettersson.
Institut für Radiumforschung, Wien.

The Menace to Civilisation: an Appeal to Men of Science.

May I ask the hospitality of the columns of Nature for an appeal to men of science throughout the world?

The enthusiastic pioneers of Victorian times, whose work underlies the fabric of modern science, always thought of themselves as beneficent agents. In them scientific ardour was joined with devotion to the welfare of humanity. They saw science releasing men from toil, improving their health and comfort, spreading toleration and promoting international understanding. Some part of these hopes has been realised, while others we may yet hope to realise.

But we are now faced with pressing and imminent dangers which the Victorians could not foresee. Science has immensely increased the destructive powers of mankind, without in the least diminishing their readiness to use those powers. It has been stated by a member of the Government that since the Armistice, "in the different civilised countries" no less than five kinds of poison gas have been invented, each more deadly than any used in the War. This sentence is not quoted to illustrate the conception of civilisation current among politicians, but merely to indicate the present tendency of research in one direction to amplify the means of destruction which will be available in the next war. At any moment a caprice of politics, or a vicissitude of international trade, may plunge us into a war which we shall be quite unable to prevent. In that war, which every year's delay will make the more deadly, the most incredible powers of destroying not only human life, but the whole apparatus of our civilisation, will be entrusted to boys of eighteen, and, for all we know, to African negroes. Science will have crushed the civilisation that gave it birth.

If the forces now at work are allowed free play this result may reasonably be regarded as not only a probability, but also a practical certainty; quite as certain, for example, as was the French Revolution when Lord Chesterfield prophesied its coming. Whether the storm will burst on us or on our grandchildren we cannot tell, but that the heavens are big with it is plain to see. The really desperate part of the position is that, so far as Europe goes, the total collapse of all that we have learnt to know as civilised life is regarded with almost complete indifference. Each nation is on a par with the man in Æsop, whose only care, when the ship was sinking, was to take up such a position that he could have the pleasure of seeing his enemy perish before he succumbed himself. So long as we have an Air Force which can destroy the other people's capital at least as soon as they destroy ours, we are quite happy, so far as Parliament and the Press are concerned, at any rate.

Is it too much to hope for something better from men and women who have had a scientific training, who have learnt in their work the essential fellowship of all servants of science, and whose consciences must tell them that it is their efforts, in whatever spirit they may have been conceived, which are now in danger of being directly responsible for the most appalling disaster in human history? It is not necessary to speak of the terror-stricken multitudes in the doomed cities, the screams of women and children in helpless anguish, the tragedy of Pompeii repeated on a thousand-fold scale; nor does it take much imagination to foresee the red ruin and breaking up of laws that will follow: can any one think that a world that has suffered such unimaginable horrors from science will hereafter tolerate it in the hope that it may do something to alleviate cancer? In destroying civilisation, science will also destroy itself.

The only hope for the world lies in the men of science. It is their paramount duty to see that the knowledge they win is used only for the good of their race and not for its destruction. The day is past when they can simply throw their discoveries out into the world and let them take their chance. In my opinion the only possible salvation lies in the immediate formation of an international league of men and women of science who shall pledge themselves not only to fight against war, but to refuse to give their assistance in any scientific capacity in the event of war coming despite their efforts to prevent it. Without trained technical assistance the warfare of the future will be impossible. If they wish to carry a rifle, by all means let them: they will not do much harm with a rifle. But a refusal to give their technical assistance would not only bring any war to a standstill, but would also be the strongest possible guarantee against it breaking out. If this measure is not taken, and promptly, we may well fear that the new order that rises from the ruins of the old will persecute science as whole-heartedly as ever did the rulers of the Middle Ages, and with better reason.

W. D. EVANS.

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The Heisenberg Theory of the Anomalous Zeeman Effect.

IN his theory for doublets Heisenberg (*Zeit. f. Physik*, 8, 273, 1922) assumes that the atom may be looked at as made of two parts: (1) the shell and (2) the valence electron. Expressing angular momenta in multiples of $h/2\pi$ and choosing the direction of the angular momentum of the shell as positive, the electron is allowed to have angular momenta $I=\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{5}{2}, \ldots$ in the $s, p, d, \ldots$ states respectively, and the shell has in all of the states the angular momentum $\frac{1}{2}$. The observed Zeeman patterns show that $I=\frac{3}{2}$ in $2p_1$ and $I=-\frac{3}{2}$ in $2p_2$. The observed energy levels show that the energy in $2p_1$ is higher than in $2p_2$. The writer experienced the following difficulty in accounting for this relative position of energy levels.

Various hypotheses can be made as to the nature of the interaction between the shell and the electron. We may suppose, for example, that the magnetic field of the electron induces a precession in the shell in a manner analogous to that in which an external magnetic field induces a precession in the electronic orbit. We then suppose, too, that the field due to the shell produces a precession of the electron. The contribution to the kinetic energy of each of these precessions is $-\mu H \cos \vartheta$, where μ, H, ϑ are respectively the magnetic moment of the shell, the field at the shell due to the electron, and the angle between the positive directions of μ and H. The contribution of both is $-2\mu H \cos \vartheta$. The mutual energy of the magnetic fields is $+\mu H \cos \vartheta$. There is no contribution to the energy of the electric field because the radius of the orbits is unchanged (Sommerfeld, "Atombau und Spektrallinien," third edition, p. 380). The energy to be added to that coming from other sources is then $-\mu H \cos \vartheta$. On this hypothesis, therefore, the $2p_1$ state has the lower energy, while the reverse is actually the case.

If there were no induced precession in the shell, but if the electronic precession should be still hypothesised, the $2p_1$ and the $2p_2$ levels would coincide.

If the shell and the electron should be supposed to have no induced precession, the energy of the magnetic field becomes the only source for the energy of separation of the $2p_2$ levels. This energy is $+\mu H \cos \vartheta$ and thus makes the $2p_1$ level the state of higher energy, as it is actually observed to be.

It seems questionable, however, whether the hypothesis just made can be maintained, for it presupposes that the dimensions of the orbits of the valence and the shell electrons are the same in the $2p_1$ and the $2p_2$ state. This may be contrary to quantum conditions if the energy of the magnetic field is considered as kinetic energy. If two electrons should be constrained to move on the opposite ends of a diameter of a circle of variable radius (as in Bohr's first helium model), the kinetic energy becomes of the form:

$$\frac{m_1 v_1^2}{2} + \frac{m_2 v_2^2}{2} + M_{12} v_1 v_2 = (m_1 + M_{12}) v_1^2,$$

where m_1, m_2, v_1, v_2 are respectively the masses and velocities of the electrons and $M_{12} v_1 v_2$ is the mutual energy of their magnetic fields. The case is formally analogous to the hydrogen atom, and a substitution in well-known formulas shows that the total energy becomes decreased if M_{12} is increased. The reason for this is traceable to a decrease in the radius of the orbit. Thus again the effect on the $2p_1$ level is opposite to that observed.

The matter of the sign of the energy in the doublet terms thus does not appear to the writer to be sufficiently clear.

The same question of sign is present in the case of triplet terms. In addition to this the $2p_2$ term of triplets does not seem to be accounted for properly by Heisenberg. His arrangement of angular momenta accounts for the energy level of the $2p_2$ state. I obtain, however, a different result for the Zeeman resolution. On going through Heisenberg's calculation his lines 5, 6, counted from the bottom of page 292 and leading to the equation $\cos \Theta = m/p_{12}$ do not appear obvious. His p_{12} is the projection of a vector in the direction J, m is the projection of the same vector in the direction H, and Θ is the angle between J and H. The above equation is then $\cos(JH) = \cos(AH)/\cos(AJ)$, which does not appear to be generally valid. It becomes correct, however, if A and J are the same. They are the same for doublets and for the $2p_1$, $2p_3$ terms of triplets, but not for the $2p_2$ term.

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Thunderstorms and Ozone.

THE question—What chemical changes, if any, are associated with atmospheric electrical discharges?—does not appear hitherto to have received a definite answer. Nitrogen peroxide and ozone are both referred to in scientific literature, although neither appears to have been satisfactorily identified, and their presence has been perhaps inferred from the phenomena observed while "sparking" air by artificial means.

No reliance can be placed upon observations made with guaiacum or starch-potassium iodide papers, and the work of the more serious investigators on ozone in the air (Pring, Proc. Roy. Soc., 1914, 90A, 204; Hayhurst and Pring, Jour. Chem. Soc., 1910, 868; Kaiser and McMaster, *Am. Chem.*, July 1, 1908, 39, 96; Henriet and Bonissy, *Comp. rend.*, 1908, 146, 977; and the older work of Houzeau, Schöne, H. de Varigny, Hached and Arny, and Thierry) has thrown no light on this subject.

Unexpectedly clear evidence on the above point was obtained by me in connexion with the severe thunderstorm which passed over the metropolis from south to north, during the early hours of July 10 last. The lightning on this occasion was generally described in the London press as the most vivid and prolonged display in living memory (*vide* NATURE, July 21, p. 113).

I have for some time been measuring the proportion of certain variable gaseous constituents in London and country air, and succeeded last spring in working out an improved method of estimating ozone, in which inaccuracies in the potassium iodide method of estimation, namely, the interference of sulphur dioxide and serious loss of iodine by volatilisation, were overcome by first removing the former, and then allowing the ozonised air to react on potassium iodide in the presence of a known volume of N/100 thiosulphate solution, which fixes the liberated iodine. The apparatus used will be described later, together with the general results.

The measurements form two series, determinations of the sulphur dioxide and nitrogen peroxide in dilute sodium bicarbonate, alternating with those of ozone, sulphur dioxide, and ammonia. Each test proceeds for about three days, and is conducted in duplicate at the village of Upminster, Essex (17 miles E.N.E. of Charing Cross), and at Messrs. Jeyes' laboratory, Plaistow, E., 5000-10,000 litres of the outside air in each case being examined. The former estimation was in progress during the storm at both places. Upminster lay on the eastern fringe of the storm track. It experienced severe lightning, but only 0·36 inches of rain fell there, as against 2 inches at the London station, which was nearer the centre. The proportion of nitrogen peroxide before, during, and after the storm (recorded in terms of 1 volume of NO_2 in . . . million volumes of air) was as follows :—

	Before.	During.	Since.
London. . . .	1 in 120 millions.	1 in 114 millions.	1 in 134 millions.
Upminster . .	1 in 350 millions.	1 in 440 millions.	1 in 400 millions.

There was, therefore, no appreciable increase in nitrogen peroxide in the air during the storm. The sulphur dioxide and ammonia remained practically constant during the above period, the proportion of the former being—London, 1 in 20 millions, Upminster, 1 in 45 millions, while the ammonia amounted to 1 in 200 millions in both.

This result has been confirmed by an examination of rain water. I have not yet collected during a thunderstorm a specimen of London rain sufficiently free from suspended particles (which completely mask its analysis) to be trustworthy; but in a bright sample collected during a thunderstorm at Upminster, the nitric acid content proved to be equivalent to a N/200,000 nitric acid solution, which is slightly under the average of several samples collected during still conditions.

The proportion of ozone present a few days before the storm was 1 in 23 millions in London, and 1 in 22 millions at Upminster, but the average amount present between July 13 and 16 was 1 in 3·2 millions in London, and 1 in 14·8 millions in the country. *There was, therefore, more than seven times the previous quantity of ozone present in London air three to six days after the storm,* and the proportion must have been appreciably higher than this at the time, owing to the subsequent loss by diffusion and convection, and to the change into oxygen, which can be readily proved to occur. A fortnight later the proportion of ozone at both places was 1 in 18·5 millions.

Confirmation of the above results has been obtained during a much less spectacular thunderstorm, which visited both stations about midday on August 24 last. A few days previously the proportion of ozone found was—London, 1 in 22·7 millions, Upminster, 1 in 18·8 millions. Measurements of the ozone had been in progress nearly twenty-four hours when the storm occurred, and were continued for the next three days. The average content for the four days was—London, 1 in 9·71 millions, Upminster, 1 in 7·8 millions, *the proportion of ozone having thus been more than doubled in each instance.*

I hope to devise a portable modification of the apparatus that will enable estimations to be completed in two or three hours, in which case much more detailed information on the subject will be obtained than is possible in three- to four-day averages.

WILLIAM C. REYNOLDS.

"Wharfedale," Upminster, Essex,
August 28.

A Method for Demonstrating the Stages in the Life History of Monocystis in Practical Class Work.

IN the text-books on practical zoology in common use in zoological laboratories, the method advocated for making preparations of the contents of the vesiculæ seminales of the earthworm for the examination of the stages in the life history of Monocystis is what is usually known as the cover-glass method (*vide* Marshall and Hurst, "Practical Zoology," 9th edition, p. 13). It is, I believe, a matter of common experience that, when this method is adopted, only a small percentage of the students succeed in finding in their own preparations all, or even the majority, of the important stages. Generally only the trophozoite and sporocyst stages are found, and demonstration specimens have to be resorted to to fill in the gaps.

This repeated failure in previous years suggested the trial of a modification of the method, and the result may be of interest to those who have charge of practical classes. The preliminaries are the same. The vesiculæ seminales (preferably the posterior lateral vesiculæ seminales, as these appear to contain more specimens) are removed from a freshly killed (with chloroform) worm, and placed in a watch-glass with about five to six times their bulk of normal salt solution. The material is teased thoroughly with needles. A drop of the fluid and particularly a portion of the teased wall of the vesicula seminalis is placed on a slide and, if desired, faintly stained with Dahlia. Cover with a cover-glass, and the preparation is ready for examination. If the operation has been rapid and the staining only slight, the trophozoites will be found to be still alive and exhibiting the characteristic gregarine movement. The encysted stages will be found embedded in the tissue of the wall of the vesicula seminalis, and it is for this reason that stress should be laid upon the inclusion of a portion of the wall in the preparation. In this situation the stages which are not usually found, *i.e.* the gametocytes in association, and more rarely gametocytes showing fragmentation into gametes, occur, as well as large numbers of sporocysts containing spores.

Below is a summary of the results (as recorded by the students themselves) obtained with a class of twenty students, one worm serving for every two students. The class was held in May.

Stages.	Percentage of Students obtaining Stages.
Trophozoite	85
Gametocytes in association . .	60
Gametocytes showing fragmentation into gametes	25
Sporocysts with spores . . .	95

As experience shows, worms vary considerably in the extent to which they are infested with Monocystis, but the above result may be taken as representative.

It may be of interest also to record that the worms used by the class had been kept in the laboratory from the previous November. The method adopted was to keep them in a tank in a compost made up of one third earth and two-thirds moist leaf-mould. The compost must be kept reasonably moist, and it was found advantageous to change it about every three weeks.

A. J. GROVE.

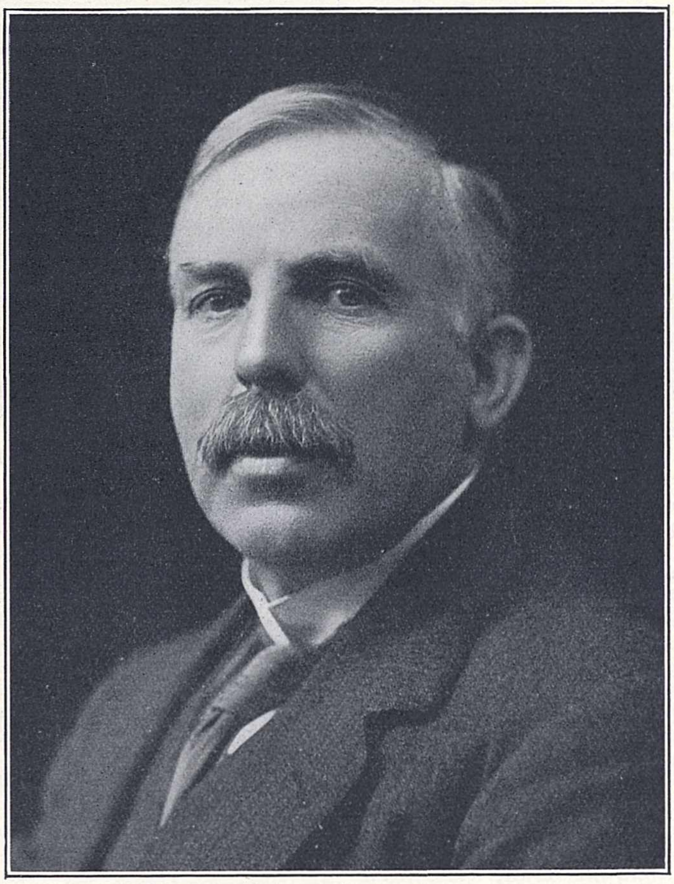
Zoological Laboratory,
The University, Sheffield,
August 21.

The British Association at Liverpool.

SIR ERNEST RUTHERFORD, F.R.S.

THE ninety-first annual meeting of the British Association for the Advancement of Science opened on Wednesday evening with a brilliant address by the president, Sir Ernest Rutherford, on the electrical structure of matter—a subject to which he has made many notable contributions and on which he is a leading exponent. He is, we believe, the youngest president appointed by the Council since the foundation of the Association in 1831. The average age of the presidents of the Association is nearly sixty-two years; and until this year the youngest presidents were Sir Arthur Rucker, Sir Joseph Thomson, and Dr. Bateson, each of whom was fifty-three years of age when holding the office.

Sir Ernest Rutherford was born at Nelson, New Zealand, on August 30, 1871, and, after graduating in the University of New Zealand, proceeded with an 1851 Exhibition Science Scholarship to Trinity College, Cambridge, where he at once took up research at the Cavendish Laboratory, leading in 1897 to a research degree and the Coutts-Trotter Scholarship. In the following year, and on the advice of Sir Joseph Thomson, he was appointed Macdonald professor of physics in McGill University, Montreal, where he remained until 1907 and continued with such remarkable success the studies of the properties of radioactive substances in which he had shown great originality and insight at Cambridge. It was while he was at Montreal that Sir Ernest Rutherford was joined by Prof. Soddy from Oxford, and together they proved by experimental evidence that radioactivity is an atomic phenomenon accompanied by chemical changes in which new types of matter are produced, that the changes must occur within the atom, and that the radioactive substances must be undergoing transformation. It was twenty-one years ago when this theory of the cause and nature of radioactivity was published in the *Philosophical Magazine*, and the advances in atomic physics and chemistry since then have been both startling and stimulating. The distinguishing characteristic of Sir Ernest Rutherford's work has always been extreme care in verifying every step by thorough experimental test, and it is on this account that a theory which at first provoked much adverse criticism has become an established scientific principle.



[*Photo: Russell and Sons, London.*

The work done by Sir Ernest Rutherford at Montreal, though so novel and suggestive, represented only the first harvest in a field which has been growing in extent and increasing in fertility ever since. While Langworthy professor of physics in the University of Manchester from 1907 to 1919, and as Cavendish professor of physics in the University of Cambridge during the past four years, he and his pupils have cultivated this field with astonishing success. Attention has been given particularly to the α-particle, which is liberated spontaneously in radioactive transformations and has proved of special service in elucidating the structure of the atom. Bombardment of the lighter elements, particularly of nitrogen and aluminium, by these swift projectiles, has disclosed the presence of hydrogen nuclei within the nuclei of some of these elements, and this work has played an important part in modern theories of the structure of matter, with which Sir Ernest Rutherford deals in his presidential address, reproduced in this week's Supplement to NATURE.

ARRANGEMENTS FOR THE MEETING.

The meeting of the British Association now being held in Liverpool is of particular importance, both by reason of the large attendance and through the weighty scientific matters under discussion. In other respects also it is noteworthy, on account of departure from what are traditional habits of the Association.

The president's address in the Philharmonic Hall was not a mere reading of written matter. The printed address was available as usual, but was given as a discourse illustrated by lantern slides and models. The address was broadcasted, and was reproduced in another hall in the city at an overflow meeting: being thus communicated to a wider audience than has ever previously been the case. No better example of the advancement of science in the Association could be made.

The Sectional programmes are extraordinarily full and exhibit an increasing tendency towards afternoon lectures as well as more numerous meetings on the last morning, September 19. At the same time the great increase in both general and sectional excursions and visits to works is loading the programme to an extent which must satisfy even the most thirsty for scientific knowledge. The Local Committee has spared no trouble to make these excursions and visits to works a success. There are about fifty-five of them, and a brief account of what visitors can see in each is contained in a dainty excursion guide, a copy of which is given to each member. Apart from its utility at the moment, this little book forms a useful companion volume to the handbook "Merseyside."

The scientific exhibition at the Central Technical School, and the soiree at the University, represent together a great development of the small sectional and other exhibits which have been a feature of many meetings. They attempt to show all that is latest in science, in apparatus, experiment, etc., and at the same time, through lecturettes and cinema exhibitions, to present much new matter in a form of more general interest than papers in the Sections addressed to specialists only. While the latter arouse the interest of the philosopher, the former seek to promote general interest in science and its application. The organisation of this exhibition and soiree has represented an enormous amount of work.

It had originally been decided to have no arrangements for the evening of Monday, September 17, but it was felt that many visiting members would like some recreation, so the Local Committee has taken several hundred seats at the Playhouse, when the Liverpool Repertory Theatre Co. will present two plays. Application for tickets, which will be free, must be made in the Reception Room, and seats will be allocated in order of application.

On Sunday morning, September 16, special services will be held in many places of worship, and Canon Barnes will preach and the Lord Mayor attend in state the service at the Lady Chapel of the Liverpool Cathedral. In the afternoon of the same day there will be an organ recital in the Great Hall at St. George's Hall.

An outstanding feature of the meeting is the number of foreign and colonial visitors. Representative men of science from Norway, Sweden, Denmark, Holland, Switzerland, France, Italy, Hungary, United States and Canada are present, as well as a representative from India.

This reunion of scientific workers from so many parts of the globe cannot but be to the advantage of science as a whole, and indirectly help the international nature of science. There seems something peculiarly suitable that such a notable gathering should be held in Liverpool, our most cosmopolitan city and port.

Probably for the first time in its history the housing question has directly touched the Association. The question of accommodation has been a very difficult one for the Local Committee, as at the present time there are practically no vacant rooms even in so large a city. Fortunately Southport, which is quite near, and has an excellent train service to Liverpool, possesses several excellent hotels, and weekly railway tickets at reduced fares are available.

Though most of the Sectional meetings are being held in the University Buildings, Sections E, F, and H meet in the city in the near neighbourhood of the Reception Room. For the general convenience of members, lunch is provided in the Students' Union and in a marquee at the University, and also in St. George's Hall alongside and opening out of the Reception Room.

Through the kindness of the Tramways Committee of the Corporation members are allowed to travel free on tramcars on showing their Association badge.

The members attending the meeting are thus enjoying a busy and profitable week. ALFRED HOLT.

The Japanese Earthquake of September 1.

By DR. CHARLES DAVISON.

SINCE November 4, 1854, the Empire of Japan has experienced no earthquake, not even in 1891, that can be compared in strength and destructiveness with that which occurred about noon on September 1. Semi-destructive shocks, or shocks capable of throwing down chimneys and stone-lamps, are not uncommon in the district round Tokyo and Yokohama, the most notable during recent years being those of February 22, 1880, June 20, 1894, December 8, 1921, and April 26, 1922. The first of these shocks is of interest as it led to an event in the history of seismology, the foundation by Prof. Milne of the Seismological Society of Japan. But the continued existence of the capital and seaport points to their long-standing immunity from destructive earthquakes, though, as they lie close to a well-known seismic zone, it may be for that very reason that this last great movement occurred in their immediate neighbourhood.

How great the disaster is we do not yet know. As usual in an earthquake of this magnitude, railway-lines are crumpled, telegraphs and telephones are destroyed, and our chief news comes, for the first time on such an occasion, by wireless. It is uncertain, too, how much of the destruction was due directly to the earthquake, how much to the fires that broke out immediately and spread at first unchecked owing to the derangement of the water-mains, and how much to the sea-waves that followed. In Yokohama, the earthquake was mainly responsible, for it left little standing for fires to work upon. In Tokyo, not a house is undamaged, and about two-thirds of the city—including, it is reported, the Imperial University, the Imperial Museum, and the

Ministry of Education—are destroyed. The most serious loss is that of the lofty steel-brick buildings recently erected. It was supposed that they would resist a shock of the utmost violence, and if their destruction was, as is probable, due to the earthquake and not to the fire, it may be necessary to prohibit their erection in the future, and this will greatly restrict the manufacturing power of the country. Estimates of the total loss of life vary widely. Some place it as high as half a million, and in Tokyo inquests have already been held on more than 32,000 bodies. There can be little doubt that the work of a few minutes has been more costly in life and treasure to Japan than a great and long-continued war.

There appear to have been no fore-shocks strong enough to give warning of the first and greatest earthquake. Among the crowd of after-shocks that followed, one was strong enough to be felt at Osaka at 2.25 P.M. on September 1. Mr. J. J. Shaw at West Bromwich recorded a second earthquake at 9 A.M. on the same day (6 P.M. Japanese time). On September 2, almost exactly twenty-four hours after the principal shock, seismographs in Great Britain revealed the occurrence of another earthquake, almost as powerful as the first, with an origin at about the same distance and in nearly the same direction as the first. No mention is made of this earthquake in the Japanese reports, unless it is the shock which on the morning of September 2 is said to have destroyed 6000 houses in the town of Kawâguchi. But its origin may have been situated more to the south and possibly near the Bonin Islands.

The number of after-shocks was unusually great. According to the Tokyo Central Observatory, 1039 were recorded between noon on September 1 and 6 A.M. on September 6, the numbers being 356 on September 1 and 2, 289 on September 3, 173 on September 4, 148 on September 5, and 63 during the first quarter of September 6, the usual decline in frequency being thus manifest. In the two months following the great earthquake of 1854, the number of after-shocks actually felt was 443. During the five days after the Mino-Owari earthquake of 1891, 808 shocks were recorded at Gifu. The number of after-shocks, however, seems to depend on the magnitude of the vertical, rather than of the horizontal, displacement; and thus, the large number following the recent earthquake may imply that the movement which caused it possessed a noticeable vertical component.

Other evidence of vertical displacement at the epicentre is provided by the arrival of the sea-waves soon after the earthquake. Little is known about these waves. They appear to have swamped the reclaimed portions of Yokohama and Tokyo and to have caused much damage along the numerous creeks and canals. Many villages along the coast of the peninsula south of Yokohama were washed away. The naval base at Yokosuka (about 10 miles south of Yokohama) was destroyed, partly by the earthquake, partly by the sea-waves. There is no evidence, however, that the waves were of great height like those of the Sanriku earthquake of 1896. And it is important to notice that, of the three cables leading to Tokyo, only one was fractured by the earthquake, the others continuing to work normally.

With regard to the position of the epicentre, we have some, though not much, evidence. The earthquake was evidently stronger at Yokohama than at Tokyo, 16 miles farther north. The sea-waves may have been caused by submarine landslips, but they were probably due to a vertical displacement of the ocean-bed. That the movement at the surface, at any rate in Tokyo Bay, was not very considerable seems to be indicated by the preservation of two of the three lines of cable. The apparent lowness of the sea-waves may have been due to the smallness of the vertical movements, but it may have resulted from a restricted area of submarine displacement, such as would be provided by an epicentral area crossing land on one or both sides of Sagami Bay, the inlet leading up to Tokyo Bay. Not much trust can be placed on the reported disappearance of the island of Oshima, which seems to be near the epicentral district, but it may have taken part in a general movement of subsidence and thus be of diminished area.

For our knowledge of the earthquakes of the Tokyo district, we are chiefly indebted to the labours of Prof. Omori. In two recent numbers of *Seismological Notes* (No. 2, 1922, pp. 1-21, and No. 3, 1922, pp. 1-30) he has described the semi-destructive earthquakes of December 8, 1921, and April 26, 1922, and the distribution of earthquake-origins in the neighbourhood of Tokyo. A glance at the map of Japan will show that the inlet consisting of Sagami Bay and Tokyo Bay runs in a northerly direction up to Tokyo, the entrance to the latter bay being known as the Uraga channel. On the west side, the inlet is bounded by the Sagami-Izu peninsula, and on the east side, by the Awa-Kazusa peninsula. During the eight years 1914–1921, 199 earthquakes originated in the country round Tokyo, and, with few exceptions, in four seismic zones, one off the east coast of the Main Island, the second in the neighbourhood of Mount Tsukuba about forty miles north-east of Tokyo, the third in and near the Awa-Kazusa peninsula, and the fourth round Hakone at the northern end of the Sagami-Izu peninsula. In other words, during these years, the immediate neighbourhood of Tokyo was seismically quiet, while the three mountainous regions surrounding the city at a distance of about forty miles, gave rise to "very frequent occurrences of earthquakes, which, though often sharply felt in the city, are harmless, as the districts in question do not belong to a great seismic zone." Then follows this remarkable prediction. "In the course of time, however, the seismic districts" referred to above "will become gradually quiet, while the Musashi plain and the Tokyo bay may, as a compensation, recommence its seismic activity, and may result in the production of a strong earthquake, probably just after a year of marked minimum of seismic frequency."

The last strong earthquake (that of April 26, 1922) originated, according to Prof. Omori, off the west coast of the province of Awa in the Uraga channel; and, he concludes, "the Awa-Kazusa peninsula and the Sagami earthquake regions, at present so active, form obviously one continuous system separated by the Uraga channel of small seismic frequency, and it was exactly at the latter locality that the . . . strong earthquake [of April 26, 1922] took place. It seems natural that a district like the Awa-Kazusa peninsula, where small shocks are taking place so frequently, does not give rise to a destructive earthquake; while a neighbouring region like the Uraga channel, which belongs to the same seismic zone, but is subject for the time to a low seismic frequency, may become the source of a strong shock." So far as the evidence at our disposal will allow us to judge, it seems to me very probable that the recent earthquake originated in the Uraga channel portion of this seismic zone and at a great depth—perhaps from 20 to 30 miles or more—below the surface.

Current Topics and Events.

SEVERAL matters of interest are referred to in the report of the Council of the British Association presented at the Liverpool meeting now in session. Major-General Sir David Bruce has been unanimously nominated by the Council to fill the office of president of the Association for the year 1924–25 (Toronto Meeting). The grateful thanks of the Association has been expressed by the Council to Sir Robert Hadfield for his generous gift designed to enable necessitous students to obtain scientific books. The gift is of 50*l*. in each of three years, and that sum, for the first year, has been distributed in grants of 10*l*. to each of five universities or colleges selected by lot, namely, University College of Bangor, North Wales; University College, Cardiff; Universities of Leeds, Liverpool, and Manchester. The Council, on behalf of the Association, joined in protesting against proposed changes in the Egyptian laws relating to antiquities, and received, through the Foreign Office and the High Commissioner, the assurance that the Egyptian Government would not modify the existing law without further careful consideration of protests received. The third grant of 250*l*. from the Caird Gift for research in radioactivity (for the year ending March 24, 1924) has been made to Prof. F. Soddy. In conformity with the rules, the Council has nominated the following new members to fill vacancies caused by retirement: Prof. W. Dalby, Dr. J. S. Flett, and Mr. C. T. Heycock, leaving two vacancies to be filled by the General Committee. The Council has nominated M. le Comte de St. Périer to be an honorary corresponding member of the Association. Arrangements for the meeting in Toronto, 1924, are in progress, and the Council has appointed a committee to assist the General Officers in this matter, including Sir D. Bruce, Sir Richard Gregory, Sir William Herdman, Prof. A. W. Kirkaldy, Prof. J. C. McLennan, Sir Ernest Rutherford, Sir Charles Sherrington, and Prof. A. Smithells. The General Committee at Hull desired the Council to consider the possibility of a meeting being held in England in 1924, following and supplementary to the Toronto Meeting. The Council does not, however, see the way clear for carrying out the suggestion.

IN an article on the magnetic work carried out at the Royal Observatory, Greenwich, which appeared in NATURE of September 1, p. 345, reference was made to the need for the removal of the recording instruments from Greenwich. The proposal to electrify railway routes in the vicinity of the observatory rendered this course necessary, and a site on the lower slopes of Holmbury Hill, Surrey, was chosen as meeting the requirements for the new station. Considerable opposition to the scheme was aroused on the plea that the site was on common land and that the necessary buildings would deface one of the best known view-points in Surrey. We now understand from Mr. L. W. Chubb, secretary of the Commons and Footpaths Preservation Society, that an alternative site has been found near Abinger Bottom, 1½ miles from Holmbury Hill. The position is on private land and is protected from interference by building operations by Abinger and Wotton commons. It is only 2¾ miles from a railway, but the Astronomer Royal and the technical advisers of the Admiralty have accepted the site as meeting the needs of a permanent magnetic observatory where the records commenced in 1840 at Greenwich may be continued.

ACCORDING to the Calcutta correspondent of the *Times*, a severe earthquake shock, lasting several minutes, was felt in Calcutta at 4 o'clock on the morning of September 10. The direction of the shock was from north-east to south-west and it extended over a wide area, slight damage to buildings being reported at Dacca, and from various stations in Assam. It is stated that the shock was the most severe since the great earthquake of 1897.

WE regret to announce the death on August 23, at the age of forty-nine, of Dr. E. F. Bashford, the first director of the Imperial Cancer Research Fund.

PROF. BOHUSLAV BRAUNER, professor of chemistry in the Bohemian University, Prague, has been elected an honorary foreign member of the French Chemical Society.

THE *Times* correspondent at Cairo reports that the Ministry of Public Works has decided to construct a special wing to the Cairo Museum, to cost 28,000*l*., for the purpose of housing the objects taken from the tomb of Tutankhamen.

SUMMER Time will cease in Great Britain, and normal time will be restored, at 3 A.M. (Summer Time) in the morning of Sunday, September 16, when the clock will be put back to 2 A.M.

DR. RAUL GAUTIER, director of the Observatory and professor of astronomy and meteorology in the University of Geneva, has been elected an honorary member of the Washington Academy of Sciences, in recognition of his prominence in geodesy and his intimate connexion with scientific work in Washington.

DR. C. M. WENYON has been appointed director-in-chief of the Wellcome Bureau of Scientific Research in succession to Dr. Andrew Balfour, who has held that post for the past ten years. Dr. Wenyon was previously director of research in the Tropics at the institution.

ACCORDING to the Journal of the Washington Academy of Sciences, Dr. C. A. Browne has been appointed chief of the United States Bureau of Chemistry, in succession to Dr. C. L. Alsberg, who resigned in July 1921. Dr. Browne has for the past sixteen years been head of the New York Sugar Trade Laboratory, and previously was chief of the sugar laboratory at the Bureau of Chemistry.

THE Western Galleries of the Science Museum, South Kensington, will be closed to the public on and after Monday, September 17, for the purpose of transferring the collections illustrating astronomy, geodesy, meteorology, geology, chemistry, physics, mining and metallurgy to the new buildings of the Science Museum now in course of erection. These collections will be placed on exhibition as soon as galleries are available for their reception.

THE Research Station, Long Ashton, Bristol, will be open to visitors on Wednesday, September 26, when the experimental work in progress will be explained by members of the staff, and in addition some of the most recent types of spraying machines and cultivators will be shown in working order by representatives of leading firms. Demonstrations of tree-stump blasting will take place at 12.45 P.M. and 2.30 P.M. The Minister of Agriculture, Sir Robert Arthur Sanders, Bart., has intimated his intention of visiting the station on this occasion.

A *Northern News Service* message from Berlin dated August 21, which appears in the *Publishers' Circular* of September 1, states that at a meeting of the leading German publishers on August 21 it was resolved to suspend entirely the publication of scientific works. Those issued during the past few months have proved to be a drug on the market, as the people who constitute the reading public for this kind of books no longer have any money to purchase them. Even the public and university libraries can no longer afford to do so.

THE field experiments on the manuring of root crops conducted at Rothamsted Experimental Station, Harpenden, provide, at this time of the year, a striking series of demonstration plots to which the attention of all interested in agriculture is invited. The potato plots show the effects of various potash manures and of the addition of increasing quantities of sulphate of ammonia to a complete fertiliser; comparative trials are also in progress using new fertilisers. On the mangold plots, the value of town refuse can be compared with that of dung, while, on the swede plots, the effect of sulphate of ammonia supplementing phosphates, potash, and dung applied at sowing time can be seen. With white turnips, comparisons are being made of the relative values of different green manuring crops which have been ploughed in. The secretary of the Station will be glad to make arrangements for parties of farmers or others desirous of inspecting the plots, or arrangements can be made on arrival at Harpenden.

APPLICATIONS are invited for the post of assistant in the pathological laboratory at Harpenden of the Ministry of Agriculture and Fisheries. Applicants must possess an honours degree in science, or similar qualification, and be proficient in zoology and botany. Among the duties of the person appointed will be the investigation and inspection of living plants in connexion with trade. Forms of application are obtainable from the Secretary of the Ministry of Agriculture and Fisheries, 10 Whitehall Place, S.W.1. They must be returned, with copies of recent testimonials, by October 1.

THE monthly meteorological chart of the North Atlantic for September issued by the Meteorological Office, Air Ministry, gives details of marine meteorology of general interest to all navigators traversing the Atlantic. The information deals with winds and ocean currents, normal isobars for the month, and limits of ice, together with the charted positions of derelicts, the northern and southern limits of Trades, and the mean paths of cyclonic disturbances. There is much on these meteorological charts which will enable a commander or officer to obtain not only the normal weather conditions for his passage, but also to foresee, by comparison with his own observations, the unusual or exceptional weather, and being forewarned he can often take advantage of the weather changes he experiences. Much time has been spent in obtaining the valuable data exhibited and any ordinary navigator can easily master the information contained. On the back of the chart Capt. L. A. Brooke Smith, the marine superintendent of the Meteorological Office, gives a discussion of a West Indian hurricane which is traced from the Tropics on September 13 of last year to the south-west coast of the British Isles on September 26 and 27, passing south-east of Newfoundland on September 23. The storm was also dealt with in the U.S. *Monthly Weather Review* for September 1922. The discussion and storm track are given chiefly to show how wireless telegraphy may be usefully applied for ascertaining the movement of such a storm when the ship is at sea.

A PAPER entitled "Le scienze fisiche e matematiche nelle opere di Dante," by Francesco Vercelli, was published in the February number of the *Rivista Marittima*. The author endeavours to show the character of Dante's ideas on arithmetic, geometry, mechanics, cosmology, meteorology, and optical phenomena by means of numerous quotations from the Divine Comedy and the "Convivio." Some of these do not seem very conclusive as regards Dante's opinions about the phenomena of Nature, and are such as may be picked out from the writings of many poets; but the majority furnish good illustrations of the ideas prevalent at the beginning of the fourteenth century, of which Dante is an excellent exponent. Thus we find under the heading of mechanics nothing but the notions of Aristotle as to why a body set in motion through the air may continue to move after the moving force has ceased to act on it. The author thinks there are some slight indications of independent thought in the direction of the true laws of motion, but the passages quoted do not seem very convincing. Dante's cosmological ideas are so closely interwoven with his great poem that it is easy enough to find passages which illustrate it (see NATURE, vol. 107, p. 428). The author devotes more space to meteorological phenomena, which are frequently alluded to in the descriptions of the different localities of the mountain of Purgatory, but none of the quotations given are of any special interest.

MESSRS. BAIRD AND TATLOCK have just issued their "Standard Catalogue of Scientific Apparatus, 1923. Vol. 1. Chemistry." The previous edition of this catalogue was published in 1914, and the outbreak of the War a few months after publication rendered it practically useless. The present edition is conceived on a larger scale than the earlier one, the volume before us—Chemistry—alone containing 954 pages as against 1283 pages of the full 1914 catalogue. Judging from this catalogue, manufacturers of chemical apparatus have fully recovered the paralysis caused by the sudden stoppage of German goods in 1914. Certain items are missing, such as German balances, but every type of balance is to be found in the list. Practically everything obtainable in 1914 can be purchased now, the only difference being that instead of the major proportion coming from Germany, most of the apparatus is manufactured in England. Prices are naturally higher than in 1914, in round figures, judging from the selection of a number of typical pieces of apparatus, about double; this may be regarded as a normal ratio, and excludes the idea of profiteering in this industry. Diligent search revealed one item—india-rubber tubing—at less than pre-War prices. Glass apparatus, now almost entirely of British manufacture, shows some price anomalies. Beakers are about 2·5 times pre-War, and heavy cast glass about three times, probably due to difficulties in manufacture; on the other hand, blown glass apparatus is generally less than double pre-War price. For example, an eight-bulb Young evaporator column is only advanced from 27*s*. to 35*s*. The catalogue has a good index, and reflects credit on the enterprise of the publishers.

THE latest special catalogue of Mr. F. Edwards, 83 High Street, Marylebone, W.1, is No. 450, entitled "Americana." It gives particulars of nearly 500 second-hand books relating to Central and South America: geography and travel, books of views, history, natural history, antiquities, etc.

Our Astronomical Column.

THE TOTAL SOLAR ECLIPSE OF SEPTEMBER 10.—As we go to press (September 11) news reaches us from the Royal Observatory, Greenwich, that the solar corona was seen through slight cloud during the total solar eclipse of Monday, September 10, and that good photographs were obtained by Mr. Worthington at Lompoc, California.

SPECTROSCOPIC PARALLAXES OF STARS OF TYPE B.—The *Astrophys. Journ.* for June contains a paper by W. S. Adams and A. H. Joy on this subject. Their research was quite independent of that by D. L. Edwards (Mon. Not. R.A.S., Nov. 1922) and is based simply on general spectral type, not on differences of intensity of particular lines. It has long been known that there is less dispersion of absolute magnitude for type B than for later types, and the authors adopt definite values for each spectral sub-division. The following is an abbreviated list of their adopted values:

Spectral Type.	Adopted Absolute Magnitude.	
	Diffuse Lines.	Sharp Lines.
	mag.	mag.
B_0	−3·1	−3·1
B_2	−1·5	−2·0
B_4	−0·6	−1·2
B_6	−0·3	−0·9
B_8	+0·1	−0·6
A_0	+0·9	+0·2
A_2	+1·7	+0·9

Adams and Joy prepared this list with the aid of 34 trigonometrical parallaxes and others derived from moving clusters, group motion, and various statistical methods.

A list then follows of the parallaxes of 300 stars, based on these values. Their spectral types are deduced from Mt. Wilson spectrograms. The Harvard types are given for comparison, and seldom differ by more than one step.

The later sub-divisions of type O have also been included, using H. H. Plaskett's notation of O_5, O_6, O_7, O_8, O_9 for the stars with dark lines that precede B_0 in the sequence. The results have been tested by plotting reduced proper motion against absolute magnitude. The function actually plotted is $0{\cdot}2m + \log\mu$, m being apparent magnitude and μ proper motion. The resulting graph is nearly a straight line, which is claimed as support for their adopted values. It is admitted that there are exceptional stars which their formulæ will not fit: on one hand, supergiants, such as Rigel; on the other, abnormally faint B-stars such as Boss 1517, for which Voûte found the trigonometrical parallax 0·074″, while the spectroscopic one is 0·005″. The authors hope that Mr. Edwards's method may serve to find the dispersion in parallax for each sub-type.

Their largest spectroscopic parallax is 0·069″ (Boss 2698), and their smallest 0·002″ (twelve stars of about the 6th magnitude).

SUNSPOT ACTIVITY.—There are signs of the beginning of the new cycle of activity. A double spot of appreciable size, followed by a train of small ones, entered the disc shortly before the end of August, and was seen near the west limb, flanked by a large facula, on September 9. It was S. Latitude 29°, and is the first high-latitude spot of considerable size in the new cycle, though some very small sporadic ones have been seen during the last year or more.

On September 9 there was a second group of similar type, but not quite so large, on the other side of the equator, which entered the disc about September 5.

The Mt. Wilson report had already noted that the activity in June was greater than for some months past, there being five days when two groups were on the disc, and one day when three groups were visible.

Research Items.

RODRICK, THE LAST OF THE VISIGOTH KINGS.—Dr. A. H. Krappe, under the title of "The Legend of Rodrick, the last of the Visigoth Kings, and the Ermumarich Cycle," has published an elaborate monograph in which he illustrates the mode in which a legend has become embedded in a tribal saga. He arrives at the source of the vast legendary current which contributed to swell the Spanish, French, Scandinavian, and German epic. It is recorded by Byzantine historians, by the Arabian compiler in southern Spain, by a German monkish chronicler, by a French jongleur, and by an Icelandic sagaman. When the epic form breaks down, the material is worked up anew in the ballads of southern and northern Europe, and while in Spain the people sing of the fatal passion of Don Rodrigo, in far-off Denmark they know of King Eric Glipping and his love for the marshall's wife. This scholarly monograph is a valuable contribution to the study of saga literature.

PREHISTORIC AMERICAN INDIAN DESIGN.—The figures of men and animals and geometric designs on prehistoric Indian pottery from the Mimbres Valley, New Mexico, are described by Dr. J. W. Fewkes in a monograph recently issued by the Smithsonian Institution. They are unique among the pottery from prehistoric North America, including human figures hunting, gambling, and engaged in various other occupations, animals of all kinds; and the geometric designs show many beautiful and striking combinations of carved, rectangular, and zig-zag elements, at times forming most intricate patterns. It is difficult to imagine how these ancient inhabitants of the south-west were able to achieve the accuracy and perfection of these involved designs without the aid of mechanical devices. The predominance of animal designs indicates that these largely formed the food of the ancient Mimbrenos. Most of the bowls were of the mortuary type, buried with the dead under the floors of the houses, and nearly all the bowls are "killed" or punctured, in order to serve the needs of the dead in the other world.

THE LIFE-HISTORY OF THE HORSE OXYURIS.—B. Schwartz records (*Philippine Journ. Sci.*, vol. 23, No. 1) observations on the life-history of *Oxyuris equi*, a nematode of common occurrence in the colon, cæcum, and rectum of horses. The egg develops rapidly, exposure to air being however requisite, and in four days contains a larva. When such eggs are swallowed by guinea-pigs, emergence of the larva occurs in the small intestine, the operculum present at one end of the egg being lifted or detached. No evidence of invasion by larvæ of the liver, lungs, or other organ could be found. The life-history of *O. equi* appears to be simple and direct. The author concludes that the eggs must be eliminated from the host before development can take place, and that horses become infected as the result of swallowing water or food which has become contaminated with the eggs. The larvæ hatch in the intestine, settle down in the cæcum and colon, and by successive moults attain sexual differentiation.

CRUSTACEA FROM PACIFIC ISLANDS.—The little group of atolls, of which Fanning Island is the chief, lies about a thousand miles south of the Hawaiian Islands and just north of the equator. A knowledge of its marine fauna is therefore important in attempting to delimit the Indo-Pacific region of marine zoogeography stretching east of Suez with a very uniform faunal facies which only dies out as it meets with the very different faunas of Western America, of Northern Japan, and of South Australia. As a contribution to this knowledge Mr. C. H. Edmondson offers a list of "Crustacea from Palmyra and Fanning Islands" (Bernice P. Bishop Museum, Bulletin 5, Honolulu, 1923). As the author was without access to much important literature on his subject, it is satisfactory to know that the identification of the more critical species is vouched for by Dr. Mary J. Rathbun (who describes two new species in an appendix) and Dr. Waldo L. Schmidt of Washington. One interesting species which reaches its northern limit on these islands is the tree-climbing coco-nut crab. It has been stated to occur at the Sandwich Islands, but according to the author is not found there. A sinister explanation of its absence is suggested by the remark: "On Fanning the species is becoming depleted, as it is highly prized as an article of food by the Gilbertese labourers."

CIRCULATION OF WATER IN SPONGES.—In an interesting paper on "The Relation of the Form of a Sponge to its Currents," published in the *Quarterly Journal of Microscopical Science* (vol. 67, Part II.), Dr. G. P. Bidder discusses the mechanics of the sponge-circulation. He emphasises the fact that in most sponges pressure-chambers are established whereby the velocity of the oscular flow is controlled. In dealing with the action of the flagella of the collared cells, by which the water is propelled through the canal system, he states that they appear as if labouring in thick gum, and suggests that "to understand microscopic physics it is a serviceable short-cut to think of the water as treacle." We doubt whether this idea will appeal to those who are familiar with the extraordinary rapidity of movement of cilia and flagella in general, or, to take quite a different example, the active dancing of the extremely minute particles in the vacuoles of the Desmid Closterium. A discussion of this problem by experts in physical science would be of great value to biologists.

DEVELOPMENT OF THE CORPUS LUTEUM IN COWS.—The Swiss Society of Natural Sciences has recently published as part of its fifty-sixth volume a magnificently illustrated memoir by Dr. Max Küpfer, entitled "Der normale Turnus in der Aus- und Rückbildung gelter Körper." Dr. Küpfer was formerly a pupil of Prof. E. Zschokke, who was the first to adopt the practice, now employed by the veterinarians of many different countries, of squeezing out the persistent *corpus luteum* or "yellow body" of the ovary as a means of inducing œstrus and thereby overcoming a frequent cause of sterility in cows and heifers. Dr. Küpfer's memoir deals with the gross changes in the anatomy of the ovary and more particularly the *corpus luteum* of cows at different stages, and the coloured figures, which occupy no less than twenty-eight plates, afford a very valuable guide to the variation in the appearances of the organ from the time of ovulation onwards in both pregnant and non-pregnant animals. The memoir is further illustrated by some excellent graphs, one of which represents the degrees of development and regression and the amount of overlapping of the *corpora lutea* dating from successive ovulation periods. The *corpus luteum* of pregnancy is stated to reach its maximum development at about the second month. There are also illustrations of cystic ovaries, which are another cause of sterility. We notice an error in the table on page 32, where it is incorrectly stated that according to Dr. Marshall sows do not ovulate spontaneously during œstrus. The memoir is provided with an excellent bibliography. It is issued from the scientific laboratory of the slaughter-house at Zürich, and is one of a series on the morphology of the female reproductive organs in mammals. We understand that the histological changes in the *corpus luteum* are to be dealt with later.

ORIGIN AND EVOLUTION OF THE ELEPHANTS.—In *La Nature* for August, Depéret and Mayet give a summary of their views upon the evolution of the mammoths and elephants from the Pliocene times to the present day. The basis of this summary has already appeared this year in an important joint paper by MM. Depéret, Mayet, and Roman published in the annals of the University of Lyons. This paper, which deals with *Elephas planifrons* and the Pliocene elephants of Europe and North Africa generally, is fully illustrated in the excellent manner usual to the publications of the University. The authors make a step forward in the division of the genus Elephas, which they now separate into eight phyletic lines which themselves fall into five groups, *i.e.* those typified by *E. meridionalis, E. antiquus, and E. primigenius* (the mammoth), all of which lines became extinct by the end of the quaternary period; and by the living forms *E. indicus*, a line which is descended from *E. namadicus*, and finally, *E. africanus*, a line of unknown ancestry. The authors agree in large measure with Osborn's view that the group is polyphyletic, but, while cutting out the genus Stegodon from any close connexion with the African elephant, go further than Osborn in the subdivision of the others.

EARLY PALÆOZOIC PLANTS IN AUSTRALIA.—Recent exploration in the mountains along the Walhalla line, in Gippsland, Victoria, shows that the earliest flora of a definite structural type, largely representing the Procormophyta, is well developed in rocks that appear to range from Upper Silurian to Upper Devonian. The Silurian graptolite, Monograptus, occurs in some of these beds, while in others the association of the molluscs Panenka and Styliola with the plants seems to suggest that the bulk of the series is Devonian. Thursophyton and Haliserites (Psilophyton) are typical components of this flora. Both the flora and fauna of these interesting beds are now being worked out by a graduate of the University of Melbourne in conjunction with Mr. F. Chapman, the palæontologist of the National Museum. A detailed comparison with the Rhynie flora should throw much light on the early history of the vegetable kingdom.

DEFECTS IN COLOUR PHOTOGRAPHS.—It is well known that in the photographic reproduction of colours there are certain defects which can only be eliminated by fine etching, that is, re-etching certain *parts* of the three plates, as shown to be necessary to the skilled workman. These outstanding defects of the three-colour process have been fully investigated by Mr. A. J. Bull, and his results are described in the current number of the Journal of the Royal Photographic Society. His method was to measure the spectra of certain colours and compare their curves with those of the same colours as reproduced. The errors are due to the inks used, and are summarised as follows:—Blues and greens become darker and greyer. Blue-greens lose their greenish hue. Pinks acquire a yellow hue. Mauves become brown. Reds lose any bluish tint that they may possess. Yellows are lightened without change of hue, but oranges and browns are well reproduced. There is a tendency for the middle tones of a black to white scale to become reddish. The lightening of yellows is due to the yellow ink being very light. The inks are transparent enough to allow of the approximate calculation of the visual effect of their superposition. There seems to be little immediate hope of getting printing inks of the theoretically correct character.

POSITIVE RAYS AND THE POLAR AURORA.—In the *Physikalische Zeitschrift* of July 1, Herr H. Bongards reviews some of the available evidence as to the nature of the aurora, and is inclined to favour the view that it is caused by highly-charged, positive argon particles, sent out with very high velocity from the sun. The well-known green line, which appears to be identical with that discovered by Wiechert in the night sky of middle latitudes, has a wave length which agrees, within the limits of observational error, with a bright line in the blue spectrum of argon, and can scarcely be the same as a faint line in the multiple-lined hydrogen spectrum. There are also two bright lines in the spectrum of the red portions of the aurora, the wave lengths of which were determined with fair accuracy by Vogel in 1871; they agree with those of two lines in the red spectrum of argon; and, while further investigation is desirable, the evidence that argon is concerned in the polar aurora seems worthy of consideration. Bongards does not consider it impossible that argon exists in the air at the height of the aurora; and suggests that it may possibly be carried up by volcanic eruptions. He, however, leans strongly to the view that argon particles (possibly nuclei without external electrons) are ejected by the sun with very high velocities, which enable them to penetrate deep into the earth's atmosphere. Since they have none of the electrons concerned in radiation, they cannot emit light until, by repeated collision with air molecules, they have lost sufficient velocity to enable them to pick up the necessary electrons; this does not occur until the velocity is so low that the Doppler effect, which appears to be small in monatomic gases, cannot be noticed.

CELLULOSE ACETATE.—The *Chemical Trade Journal* for August 10 contains an article on cellulose acetate, a material which was first prepared by Schutzenberger in 1865, but remained a curiosity until Cross (1894) obtained it by the action of acetyl chloride and zinc acetate on cellulose. Cellulose acetate is the basis of aeroplane "dope" (it renders taut the fabric on the wings), lacquers, non-flaming celluloid materials, etc. These applications are described fully in the article, together with the more recent processes of manufacture and the important question of suitable solvents for the acetate.

THE PATHS OF ELECTRONS IN SOLUTION.—A paper on this subject, by L. Pisarjevski and M. Rosenberg, appears in the Jour. Russ. Phys.-Chem. Soc. (1923, 54, 533-547). When potassium iodide solutions are electrolysed, using spark electrodes, potassium hydroxide and iodine are liberated at each electrode. If starch paste be added to such solutions, a blue streak appears at the passage of each spark, which may go vertically through the solution for a distance of 9 cm., if a commutator be used, and then spreads out. The addition of phenolphthalein to the solutions produces a red streak under these conditions, which follows a more zig-zag path than the blue one, and also spreads out at its greatest depth, the coloration in both cases disappearing in about 30 seconds. These streaks may be deviated by applying a magnetic field to the solutions. The above phenomenon is explained as being due to the passage of high velocity electrons from the electrodes into the solutions; the concussion of these electrons with iodine ions liberates further electrons which again collide with ions in solution, and leave the iodine as free atoms. The free electrons also combine with potassium ions, neutralising their positive charges, and producing free potassium. It is thus possible visually to demonstrate that processes of oxidation involve the loss of electrons, and the reverse.

Brazilian Meteorological Service, 1921–23.

A SHORT report issued by Dr. Sempais Ferraz, the director of the Brazilian Meteorological Service, contains an account of the work accomplished under his auspices since its inauguration as an independent service in June 1921. Prior to this date, meteorological activities in Brazil were carried out by departments primarily constituted for some other purpose, and were confined to researches in pure climatology. What little forecasting was done was available only in the capital. No publications were issued except the Year-book for 1910 and "Instructions to Observers." With the progress of meteorology and the resulting rapid creation of new services, this dependence became impossible, and in June 1921 an independent meteorological service was established.

The numbers of second- and third-order climatological stations have been increased from 51 and 46 to 74 and 78 respectively. Rainfall stations and cooperative stations, of which there were 31 and 26 respectively in May 1921, now number 57 and 180. Inspections which were previously almost non-existent are now actively carried out all over the country. Year-books have been published for each of the years 1911–18, and those for 1919 and 1920 are in the press, while a book of Normals has also been issued. Whereas no data were published in the newspapers prior to 1921, each station is now obliged to publish fortnightly reports, and those stations that are located in capitals of States issue daily weather summaries.

Daily forecasts for the Southern States, based on synoptic data from 80 stations in Brazil, 18 in the Argentine, and 6 in Uruguay, are distributed from Rio de Janeiro and St. Paulo by telegraph or telephone. Two additional distributive centres are being established this year in St. Catherina and Parana. Forecasts are broadcasted by radio-telephone from Corcavado, while Rio's radio station sends out synoptic data and forecasts for the night and following days. A storm-signal service is in operation along the coast, and every four hours the coastal radio stations, 12 in number, broadcast the weather at the time. In the large towns flags are used to indicate the probable weather. Owing to the topographical conditions of the country, long experience is required in dealing with wind and pressure data. Empirical rules have had to be devised to meet the special circumstances. These are to be described in a forthcoming memoir entitled "Forecasting in Brazil."

Provision is being made for the study of agricultural meteorology by the establishment of stations modelled on those which formerly existed in Russia. There are at present eight of these stations in operation. A ten-days' bulletin is now published in all the leading newspapers, setting out the condition of the most important crops, pasture lands, and roads. Abridged reports are published monthly in the magazines. Phenological observations are also made.

All the rainfall data are under revision, and an atlas is to be published shortly which will include a general discussion of the different zonal dry and wet seasons. A flood service for the Parahyba river has been inaugurated, and a similar service is being arranged for the Amazon, where floods occasion considerable destruction amongst cattle.

Pilot-balloon observations are now made at seven stations. The establishment of a kite station in Alegrete (Rio Grande do Sul) is expected to reveal interesting data of the secondary circulation in a region which Brazilian meteorologists have described as the "turn-table" of moving highs and a frequent path of outgoing depressions. A second kite station to be established at Ceara is expected to furnish an explanation of the curious irregular droughts of north-eastern Brazil and a possible method of forecasting them. It is hoped that the pursuit of aerological research in Brazil, besides its practical assistance to aviation, "will help the eminent meteorologists of the world in their search for the missing links of general dynamic theories of the atmosphere."

This record of twenty months' work is all the more gratifying when account is taken of the difficulties which, as the author points out, beset meteorological activity in Brazil. Brazil has a highly intellectual *élite*, but the mass of the people have scarcely any education. Observers have to be paid, as voluntary co-operation at present is unavailable. P. I. M.

Sir Isaac Newton and the S.P.C.K.

SOME recent references which a correspondent has recently had occasion to make to Thomas Hollis's "Memoirs," published in 1780 (4to, 2 vols.), have led to the unearthing by him of an interesting draft letter attributed to Sir Isaac Newton, of which no mention is made in Brewster's "Life." The chronicler relates that, in September 1764, Mr. Hawksbee, son of Mr. Hawksbee, sometime clerk to the Royal Society, waited upon Mr. Hollis with the copy of a paper written by Sir Isaac Newton, containing minutes of his opinion against a proposal which had been made to the Royal Society to accommodate the members of the Society for Promoting Christian Knowledge, then newly instituted, with the use of the Society's house for its meetings. Mr. Hawksbee, the father, had shown Hollis the original in Sir Isaac's own handwriting, but could not be prevailed on to part with it. He goes on to say that Hollis was glad, however, to obtain a copy in Hawksbee's handwriting, from his son, a soldier in the artillery.

In 1698–9 the S.P.C.K. was beginning to take definite shape as a result of the efforts of a small band of enthusiasts. Indeed, a tentative plan of constitution was put forward about then by Dr. Bray, who suggested that "these persons" be incorporated by charter as [like] the Royal Society, and Sons of the Clergy; and be thereby empowered to "meet and consult as often as there shall be occasion." Sir Isaac's letter was drawn up apparently while the Royal Society was in occupation at Gresham College, and in the early days of the S.P.C.K. Sir Isaac says, "I never heard of them before."

Subjoined is the letter referred to above. Its terms are of singular interest as a defence against encroachment:

"We have a reputation abroad, and the Society for Promoting Christian Knowledge, are scarce known at home; I never heard of them before. And to admit them into our bosom would be, in a little time, to share our reputation with them.

"We are incorporated by the crown; and to herd ourselves with a club not yet incorporated, would be ingratitude to our Founder.

"Our house was built by benefactions; and to divert it to other uses than our benefactors intended would be ingratitude to their memory; and a discouragement to future benefactions.

"If we once lend our house, time will make custom, and custom will give right: It is easier to deny in the beginning than afterward.

"It is a fundamental rule of the Society not to meddle with religion; and the reason is, that we may give no occasion to religious bodies to meddle with us.

"The Society for Promoting Christian Knowledge, have a splendid title, but we are to regard not names, but things. If all their members are not men of exemplary lives and conversation, some of them, by misdemeanors, may bring reflections upon us; and why should we run the hazard?

"If we comply, we may dissatisfy some of those that are against it; especially those that are of other religions, and make them leave our meetings, which are already too thin.

"There are many vestries in London; and it is more proper for a religious society to meet in a vestry or —— than in the house of a society which is mixed of men of all religions, and meddles with none.

"Those of the Christian Society have dining rooms of their own, and may lend them by turns to their meetings. And the tenth commandment is, 'Thou shalt not covet thy neighbour's house.'

"This proposal can be of no advantage to us; but may prove disadvantageous; and we have, all of us, at our admission, promised, under our hands, to consult the good of the society; and ought not to break the fundamental covenant upon which we were admitted."

Mechanism of Stomatal Movement in Plants.

IT has been generally recognised for a long time past that the stomata of the leaf opened when more water was absorbed by the guard cells and closed when water passed from the guard cells into the surrounding tissues. It is also frequently assumed that the mechanism by which this water exchange takes place must be associated with the presence of green chloroplasts in the guard cells, the other epidermal cells being usually free from chlorophyll.

The mechanism by which the osmotic concentration of the cell sap of the guard cell is controlled has, however, remained obscure; of late years experimental work has thrown light upon this problem, and a valuable summary of this work is given by Friedl Weber in *Die Naturwissenschaften*, Vol. 11, Heft 17, April 27. Lloyd's work had shown that the movement of the guard cells is not connected with the direct photosynthesis of carbon dioxide by the guard cells, the cells around the closed stoma at night being packed with starch, while in the early morning, in daylight, the starch rapidly hydrolyses and the stoma opens.

Iljin's series of papers now suggest that the varying activity of diastatic enzymes under different conditions are intimately associated with the stomatal mechanism. Iljin showed that with stomata closed the guard cells were usually full of starch, the starch disappearing as the stomata open. Further experiments showed that sodium and potassium salts accelerated starch hydrolysis, while calcium salts prevented it; inorganic anions produced less effect, but citrates and acetates exerted considerable effect.

The effect of the various salts upon the reaction of the cell has to be carefully considered, the slightest increase in hydrion concentration favouring starch hydrolysis and stomatal opening; the slightest decrease, starch accumulation and stomatal closure. The reaction of a stoma to these various factors differs with the plant, halophytes, for example, showing themselves very insensitive to changes in salt concentration, while a plant like *Rumex acetosa*, with very acid sap, is especially sensitive. It is clear that our conception of the mechanism of control of stomatal aperture will require re-examination in the light of this interesting work. Thus Linsbauer's observations on the movement of the guard cells with change of light intensity, or with alterations in the carbon dioxide content of the air, may find their explanation in the consequent alteration of reaction in the cell sap of the guard cell.

University and Educational Intelligence.

DURHAM.—As a result of the recent decision of the council of Armstrong College to build a College Library, all practising members of the Northern Architectural Association, and a few architects in other parts of Great Britain, were invited to submit competitive designs for the building. The first premium has been awarded to Mr. A. Dunbar Smith, who has been appointed architect of the library, and work will proceed forthwith. The building will consist of a reading-room seating 122 readers, storage space for 175,000 volumes, with accommodation for 55 research students, administrative rooms, and photographic laboratory, and is so designed that additional storage space for 60,000 volumes may be added when required.

MANCHESTER.—On Tuesday, September 11, Sir George Beilby opened the new buildings to be occupied by the Department of Metallurgy in the University. Although founded in 1906, the home of the Department has so far been merely a few laboratories loaned by the Chemistry Department. Especially from the point of view of the research workers this arrangement was far from satisfactory. In the new buildings four research laboratories will be available, in addition to general laboratories for pyrometry, mechanical testing, and metallography. A small foundry and machinery room together with the heat-treatment laboratory will further offer facilities both for teaching and research which have hitherto been incompletely available. The main general laboratory, named after Henry Cort, the eighteenth-century metallurgist, the inventor of rolling metals in grooved rolls and a pioneer in connexion with the puddling process, is well equipped for the determination of the physical properties of metals at temperatures above the normal. A small laboratory is devoted to fuel examinations, so that it may be claimed that the new buildings afford excellent facilities for both teaching and research in metallurgy, metallography, and fuel. Since 1910 sixty papers have been published in recognised journals dealing with the research work done in the Department. Among the more important of the subjects investigated may be cited work on high-speed steel, the growth of cast iron on repeated heatings, chromium steels, including stainless steel, the influence of gases on iron and steel, the production of high-pressure castings, and the hardness and elastic limits of metals both at and above room temperatures. On the foundation laid by Prof. H. B. Dixon and continued by his successors in the chair of metallurgy, Profs. H. C. H. Carpenter and C. A. Edwards, an edifice worthy of their labours has at length been erected.

THE following free public Gresham lectures will be delivered at Gresham College, Basinghall Street, E.C., at 6 o'clock on the dates given: Astronomy, by A. R. Hinks, on October 9, 10, 11, and 12; Physic, by Sir Robert Armstrong-Jones, on October 16, 17, 18, and 19; and Geometry, by W. H. Wagstaff, on October 23, 24, 25, and 26.

Societies and Academies.

PARIS.

Academy of Sciences, August 20.—M. Guillaume Bigourdan in the chair.—A. **Lacroix**: The constitution of the Rockall bank. The island of Rockall emerges from a submarine bank defined by depths of 183 metres, and measures about 70 miles. Blocks of basalt have been frequently found on this bank by fishermen and by systematic dredging. Two views have been put forward as to the origin of these blocks. Forbes suggested transportation by glaciers from Iceland or Jan Mayen island, but G. A. J. Cole considers them as constituting the debris of a submerged basaltic plateau, and this view was accepted by Judd. Detailed examination and chemical analysis of the rocks collected by Charcot in 1921 on the Rockall bank confirms Cole's hypothesis.—Charles **Richet**: The influence of removal of the spleen in cases of insufficient feeding. Details of experiments lasting 126 days on five dogs without spleens and four normal dogs, as controls.—Paul **Vuillemin**: Variation and fluctuation in the number of stigmata of Papaver. —Charles **Nordmann**: The mechanism of hovering flight and the morphology of hovering birds.—N. Vasilesco **Karpen**: The electromotive force of batteries, chemical affinity, and molecular attraction. The formulæ for the E.M.F. of a Daniell cell given by Nernst and by Helmholtz are regarded by the author as inconsistent, and other objections are raised against the Nernst expression. A modified Nernst theory is proposed based on the Laplacian attraction exerted on the molecules and ions situated at the level of the surface of separation between two different media.—L. **Bert**: The preparation and application to organic syntheses of the magnesium derivative of *p*-bromcumene. *p*-Bromcumene has not hitherto been utilised in syntheses by the Grignard reaction, on account of its high price. Recently, isopropyl alcohol has been obtainable commercially at a low price, and this can readily be converted into isopropyl bromide, cumene, and *p*-bromcumene, with good yields. Details are given of the best method of preparing the magnesium compound of *p*-bromcumene and of some compounds prepared by means of it.—G. **Vavon** and D. **Ivanoff**: Catalytic hydrogenation and steric hindrance. The study of some nonanones. Four saturated C_9 ketones were studied, dipropylacetone, methylethylpropylacetone, dimethyldiethylacetone, and hexamethylacetone. Both the formation of oxims, and of phenylhydrazones, as well as the catalytic hydrogenation of the ketones in the presence of platinum, follow the law of steric hindrance. —P. **Lebeau**: The quantity and the nature of the gases evolved by solid combustibles under the action of heat in a vacuum: anthracites. The volume of gas given by various combustibles is not a function of the percentage of volatile matter. Anthracites, poor in volatile matter, give volumes of gas of the same order as bituminous coals. The gas from anthracite contains high proportions of hydrogen.—M. de **Rohan-Chabot**: Magnetic measurements in Angola and in Rhodesia by the Rohan-Chabot expedition. Observations taken in 1912 and 1913 at 44 stations in Angola and 3 in Rhodesia are given in tabular form.—Fernand **Chodat** and A. **Kotzareff**: The difference between pathological and normal sera and the autophylactic property of the latter.—A. **Paillot**: A new flagellosis of an insect and a process of natural infection not hitherto described.—C. **Levaditi** and S. **Nicolau**: The persistence of the neurovaccine in the testicle, the ovary, and the lung of animals having acquired anti-vaccinal immunity.

SYDNEY

Royal Society of New South Wales, July 4.—Mr. R. H. Cambage, president, in the chair.—G. J. **Burrows** and F. **Eastwood**: Molecular solution volumes in ethyl alcohol. The authors have measured the densities of alcoholic solutions of various organic compounds, and calculated their molecular solution volumes. It has been found that the solution of a non-associated solute in alcohol causes a contraction in volume of 20 c.c. per gram molecule of solute, and that a smaller contraction indicates that the solute is associated in the liquid state.—E. **Cheel**: Two additional species of Leptospermum. Two additional species of plants belonging to the tea-tree group were described. One species, namely, *Leptospermum coriaceum*, was originally described by Baron von Mueller as a distinct species, but was afterwards merged as a synonym with the common "sand stay" or coastal tea-tree of N. S. Wales (*L. lævigatum*). Certain structural characters, however, as well as geographical range from Sandringham in Victoria through Murray Bridge in S. Australia to Ooldea on the Transcontinental Line, serve to distinguish this species. The second species, which may be called the "small-fruited tea-tree" (*L. microcarpum*) is confined chiefly to the northern parts of N. S. Wales and Queensland. It has smooth whip-stick-like branches, and sheds its bark like some of the gum-trees.—A. R. **Penfold**: The essential oils of *Callistemon lanceolatus* and *C. viminalis*. The essential oils from two well-known "bottle brushes," *Callistemon lanceolatus* and *C. viminalis*, were described. The former inhabits the swampy situations of the coast extending to about Gloucester, while the latter is a denizen of the banks of the rivers of the far north coast and extends into Queensland. The essential oils were of a pale yellow colour, and were practically identical with a medicinal eucalyptus oil. Unfortunately, the low percentage yield of oil, 0·2 per cent., precludes their successful exploitation, despite their abundance, on account of the higher yield of 2 to 3 per cent. obtainable from the eucalypts.

Official Publications Received.

Universidad Nacional de La Plata Museo. Habitantes Neolíticos del lago Buenos Aires: Documentos para la Antropologia física de la Patagonia Austral. Por Dr. José Imbelloni. Pp. 85-160. (Buenos Aires.)

Bernice P. Bishop Museum. Bulletin 4: Report of the Director for 1922. By Herbert E. Gregory. Pp. 38. (Honolulu, Hawaii.)

Loughborough College, Leicestershire. Calendar, Session 1923-24. Pp. xiv+213+5 plates. (Loughborough.)

Prospectus of University Courses in the Municipal College of Technology, Manchester. Session 1923-24. Pp. 225. (Manchester.)

Department of the Interior: Bureau of Education. Bulletin, 1923, No. 8: Significant Movements in City School Systems. By W. S. Deffenbaugh. Pp. 28. (Washington: Government Printing Office.)

State of Illinois. Department of Registration and Education: Division of the Natural History Survey. Bulletin, Vol. 14, Art. 8: First Report on a Forestry Survey of Illinois. By Robert B. Miller. Pp. vi+291-377 +27 plates. Bulletin, Vol. 14, Art. 9: The Determination of Hydrogen Ion Concentration in connection with Freshwater Biological Studies. By Victor E. Shelford. Pp. iv+379-395. (Urbana, Ill.)

Field Museum of Natural History. Report Series, Vol. 6, No. 2: Annual Report of the Director to the Board of Trustees for the Year 1922. (Publication 213.) Pp. v+82-163. (Chicago.)

Field Museum of Natural History. Anthropological Series, Vol. 6, No. 5: The Hopewell Mound Group of Ohio. By Warren K. Moorehead. (Publication 211.) Pp. 75-185+48 plates. Anthropological Series, Vol. 14, No. 2: The Tinguian; Social, Religious, and Economic Life of a Philippine Tribe. By Fay-Cooper Cole; with a Chapter on Music by Albert Gale. (Publication 209.) Pp. vi+231-493+83 plates. (Chicago.)

Merchant Venturers' Technical College. Calendar for the Sixty-eighth Session, 1923-24. Pp. 53. (Bristol.) 6*d*.

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The Electrical Structure of Matter.[1]

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IT was in 1896 that this Association last met in Liverpool, under the presidency of the late Lord Lister, that great pioneer in antiseptic surgery, whose memory is held in affectionate remembrance by all nations. His address, which dealt mainly with the history of the application of antiseptic methods to surgery and its connexion with the work of Pasteur, that prince of experimenters, whose birth has been so fittingly celebrated this year, gave us in a sense a completed page of brilliant scientific history. At the same time, in his opening remarks, Lister emphasised the importance of the discovery by Röntgen of a new type of radiation, the X-rays, which we now see marked the beginning of a new and fruitful era in another branch of science.

The visit to Liverpool in 1896 was for me a memorable occasion, for it was here that I first attended a meeting of this Association, and here that I read my first scientific paper. But of much more importance, it was here that I benefited by the opportunity, which these gatherings so amply afford, of meeting for the first time many of the distinguished scientific men of Great Britain and the foreign representatives of science who were the guests of this city on that occasion. The year 1896 has always seemed to me a memorable one for other reasons, for on looking back with some sense of perspective we cannot fail to recognise that the last Liverpool meeting marked the beginning of what has been aptly termed the heroic age of physical science. Never before in the history of physics has there been witnessed such a period of intense activity when discoveries of fundamental importance have followed one another with such bewildering rapidity.

The discovery of X-rays by Röntgen had been published to the world in 1895, while the discovery of the radioactivity of uranium by Becquerel was announced early in 1896. Even the most imaginative of our scientific men could never have dreamed at that time of the extension of our knowledge of the structure of matter that was to develop from these two fundamental discoveries, but in the records of the Liverpool meeting we see the dawning recognition of the possible consequences of the discovery of X-rays, not only in their application to medicine and surgery, but also as a new and powerful agent for attacking some of the fundamental problems of physics. The address of Sir J. J. Thomson, president of Section A, was devoted mainly to a discussion of the nature of the X-rays, and the remarkable properties induced in gases by the passage of X-rays through them—the beginning of a new and fruitful branch of study.

In applied physics, too, this year marked the beginning of another advance. In the discussion of a paper which I had the honour to read, on a new magnetic detector of electrical waves, the late Sir William Preece told the meeting of the successful transmission of signals for a few hundred yards by electric waves which had been made in England by a young Italian, G. Marconi. The first public demonstration of signalling for short distances by electric waves had been given by Sir Oliver Lodge at the Oxford Meeting of this Association in 1894. It is startling to recall the rapidity of the development from such small beginnings of the new method of wireless intercommunication over the greatest terrestrial distances. In the last few years this has been followed by the even more rapid growth of the allied subject of radiotelephony as a practical means of broadcasting speech and music to distances only limited by the power of the transmitting station. The rapidity of these technical advances is an illustration of the close interconnexion that must exist between pure and applied science if rapid and sure progress is to be made. The electrical engineer has been able to base his technical developments on the solid foundation of Maxwell's electromagnetic theory and its complete verification by the researches of Hertz, and also by the experiments of Sir Oliver Lodge in the University of Liverpool—a verification completed long before the practical possibilities of this new method of signalling had been generally recognised. The later advances in radiotelegraphy and radiotelephony have largely depended on the application of the results of fundamental researches on the properties of electrons, as illustrated in the use of the thermionic valve or electron tube which has proved such an invaluable agent for both the transmission and reception of electric waves.

It is of great interest to note that the benefits of this union of pure and applied research have not been one-sided. If the fundamental researches of the workers in pure science supply the foundations on which the applications are surely built, the successful practical application in turn quickens and extends the interest of the investigator in the fundamental problem, while the development of new methods and appliances required for technical purposes often provides the investigator with means of attacking still more difficult questions. This important reaction between pure and applied science can be illustrated in many branches of knowledge. It is particularly manifest in the industrial development of X-ray radiography for therapeutic and industrial purposes, where the development on a large scale of special X-ray tubes and improved methods of excitation has given the physicist much more efficient tools to carry out his researches on the nature of the rays themselves and on the structure of the atom. In this age no one can draw any sharp line of distinction

[1] Inaugural address delivered to the British Association at Liverpool on September 12.

between the importance of so-called pure and applied research. Both are equally essential to progress, and we cannot but recognise that without flourishing schools of research on fundamental matters in our universities and scientific institutions technical research must tend to wither. Fortunately there is little need to labour this point at the moment, for the importance of a training in pure research has been generally recognised. The Department of Scientific and Industrial Research has made a generous provision of grants to train qualified young men of promise in research methods in our scientific institutions, and has aided special fundamental researches which are clearly beyond the capacity of a laboratory to finance from its own funds. Those who have the responsibility of administering the grants in aid of research for both pure and applied science will need all their wisdom and experience to make a wise allocation of funds to secure the maximum of results for the minimum of expenditure. It is fatally easy to spend much money in a direct frontal attack on some technical problem of importance when the solution may depend on some addition to knowledge which can be gained in some other field of scientific inquiry possibly at a trifling cost. It is not in any sense my purpose to criticise those bodies which administer funds for fostering pure and applied research, but to emphasise how difficult it is to strike the correct balance between the expenditure on pure and applied science in order to achieve the best results in the long run.

It is my intention here to refer very briefly to some of the main features of that great advance in knowledge of the nature of electricity and matter which is one of the salient features of the interval since the last meeting of this Association in Liverpool.

In order to view the extensive territory which has been conquered by science in this interval, it is desirable to give a brief summary of the state of knowledge of the constitution of matter at the beginning of this epoch. Ever since its announcement by Dalton the atomic theory has steadily gained ground, and formed the philosophic basis for the explanation of the facts of chemical combination. In the early stages of its application to physics and chemistry it was unnecessary to have any detailed knowledge of the dimensions or structure of the atom. It was only necessary to assume that the atoms acted as individual units, and to know the relative masses of the atoms of the different elements. In the next stage, for example, in the kinetic theory of gases, it was possible to explain the main properties of gases by supposing that the atoms of the gas acted as minute perfectly elastic spheres. During this period, by the application of a variety of methods, many of which were due to Lord Kelvin, rough estimates had been obtained of the absolute dimensions and mass of the atoms. These brought out the minute size and mass of the atom and the enormous number of atoms necessary to produce a detectable effect in any kind of measurement. From this arose the general idea that the atomic theory must of necessity for ever remain unverifiable by direct experiment, and for this reason it was suggested by one school of thought that the atomic theory should be banished from the teaching of chemistry, and that the law of multiple proportions should be accepted as the ultimate fact of chemistry.

While the vaguest ideas were held as to the possible structure of atoms, there was a general belief among the more philosophically minded that the atoms of the elements could not be regarded as simple unconnected units. The periodic variations of the properties of the elements brought out by Mendeléeff were only explicable if atoms were similar structures in some way constructed of similar material. We shall see that the problem of the constitution of atoms is intimately connected with our conception of the nature of electricity. The wonderful success of the electromagnetic theory had concentrated attention on the medium or ether surrounding the conductor of electricity, and little attention had been paid to the actual carriers of the electric current itself. At the same time the idea was generally gaining ground that an explanation of the results of Faraday's experiments on electrolysis was only possible on the assumption that electricity, like matter, was atomic in nature. The name "electron" had even been given to this fundamental unit by Johnstone Stoney, and its magnitude roughly estimated, but the full recognition of the significance and importance of this conception belongs to the new epoch.

For the clarifying of these somewhat vague ideas, the proof in 1897 of the independent existence of the electron as a mobile electrified unit, of mass minute compared with that of the lightest atom, was of extraordinary importance. It was soon seen that the electron must be of a constituent of all the atoms of matter, and that optical spectra had their origin in their vibrations. The discovery of the electron and the proof of its liberation by a variety of methods from all the atoms of matter was of the utmost significance, for it strengthened the view that the electron was probably the common unit in the structure of atoms which the periodic variation of the chemical properties had indicated. It gave for the first time some hope of the success of an attack on that most fundamental of all problems—the detailed structure of the atom. In the early development of this subject science owes much to the work of Sir J. J. Thomson, both for the boldness of his ideas and for his ingenuity in developing methods for estimating the number of electrons in the atom, and in probing its structure. He early took the view that the atom must be an electrical structure, held together by electrical forces, and showed in a general way lines of possible explanation of the variation of physical and chemical properties of the elements, exemplified in the periodic law.

In the meantime our whole conception of the atom and of the magnitude of the forces which held it together were revolutionised by the study of radioactivity. The discovery of radium was a great step in advance, for it provided the experimenter with powerful sources of radiation specially suitable for examining the nature of the characteristic radiations which are emitted by the radioactive bodies in general. It was soon shown that the atoms of radioactive matter were undergoing spontaneous transformation, and that the characteristic radiations emitted, namely, the α-, β-, and γ-rays, were an accompaniment and consequence of these atomic explosions. The wonderful succession of changes that occur in uranium and thorium, more than thirty in number, was soon disclosed and simply interpreted on the transformation theory. The radioactive elements provide us for the first time with a glimpse into Nature's laboratory, and allow us to watch and study, but not to control, the changes that have their origin in the heart of the radioactive atoms. These atomic explosions involve energies which are gigantic compared with those involved in any ordinary physical or chemical process. In the majority of cases an α-particle is expelled at high speed, but in others a swift electron is ejected often accompanied by a γ-ray, which is a very penetrating X-ray of high frequency. The proof that the α-particle is a charged helium atom for the first time disclosed the importance of helium as one of the units in the structure of the radioactive atoms, and probably also in that of the atoms of most of the ordinary elements. Not only then have the radioactive elements had the greatest direct influence on natural philosophy, but in subsidiary ways they have provided us with experimental methods of almost equal importance. The use of α-particles as projectiles with which to explore the interior of the atom has definitely exhibited its nuclear structure, has led to artificial disintegration of certain light atoms, and promises to yield more information yet as to the actual structure of the nucleus itself.

The influence of radioactivity has also extended to yet another field of study of fascinating interest. We have seen that the first rough estimates of the size and mass of the atom gave little hope that we could detect the effect of a single atom. The discovery that the radioactive bodies expel actual charged atoms of helium with enormous energy altered this aspect of the problem. The energy associated with a single α-particle is so great that it can readily be detected by a variety of methods. Each α-particle, as Sir William Crookes first showed, produces a flash of light easily visible in a dark room when it falls on a screen coated with crystals of zinc sulphide. This scintillation method of counting individual particles has proved invaluable in many researches, for it gives us a method of unequalled delicacy for studying the effects of single atoms. The α-particle can also be detected electrically or photographically, but the most powerful and beautiful of all methods is that perfected by Mr. C. T. R. Wilson for observing the track through a gas, not of an α-particle alone, but of any type of penetrating radiation which produces ions or of electrified particles along its path. The method is comparatively simple, depending on the fact, first discovered by him, that if a gas saturated with moisture is suddenly cooled each of the ions produced by the radiation becomes the nucleus of a visible drop of water. The water-drops along the track of the α-particle are clearly visible to the eye, and can be recorded photographically. These beautiful photographs of the effect produced by single atoms or single electrons appeal, I think, greatly to all scientific men. They not only afford convincing evidence of the discrete nature of these particles, but also give us new courage and confidence that the scientific methods of experiment and deduction are to be relied upon in this field of inquiry; for many of the essential points brought out so clearly and concretely in these photographs were correctly deduced long before such confirmatory photographs were available. At the same time, a minute study of the detail disclosed in these photographs gives us most valuable information and new clues on many recondite effects produced by the passage through matter of these flying projectiles and penetrating radiations.

In the meantime a number of new methods had been devised to fix with some accuracy the mass of the individual atom and the number in any given quantity of matter. The concordant results obtained by widely different physical principles gave great confidence in the correctness of the atomic idea of matter. The method found capable of most accuracy depends on the definite proof of the atomic nature of electricity and the exact valuation of this fundamental unit of charge. We have seen that it was early surmised that electricity was atomic in nature. This view was confirmed and extended by a study of the charges carried by electrons, α-particles, and the ions produced in gases by X-rays and the rays from radioactive matter. It was first shown by Townsend that the positive or negative charge carried by an ion in gases was invariably equal to the charge carried by the hydrogen ion in the electrolysis of water, which we have seen was assumed, and assumed correctly, by Johnstone Stoney to be the fundamental unit of charge. Various methods were devised to measure the magnitude of this fundamental unit; the best known and most accurate is Millikan's, which depends on comparing the pull of an electric field on a charged droplet of oil or mercury with the weight of the drop. His experiments gave a most convincing proof of the correctness of the electronic theory, and gave a measure of this unit, the most fundamental of all physical units, with an accuracy of about one in a thousand. Knowing this value, we can by the aid of electrochemical data easily deduce the mass of the individual atoms and the number of molecules in a cubic centimetre of any gas with an accuracy of possibly one in a thousand, but certainly better than one in a hundred. When we consider the minuteness of the unit of electricity and of the mass of the atom, this experimental achievement is one of the most notable even in an era of great advances.

The idea of the atomic nature of electricity is very closely connected with the attack on the problem of the structure of the atom. If the atom is an electrical structure it can only contain an integral number of charged units, and, since it is ordinarily neutral, the number of units of positive charge must equal the number of negative. One of the main difficulties in this problem has been the uncertainty as to the relative part played by positive and negative electricity in the structure of the atom. We know that the electron has a negative charge of one fundamental unit, while the charged hydrogen atom, whether in electrolysis or in the electric discharge, has a charge of one positive unit. But the mass of the electron is only 1/1840 of the mass of the hydrogen atom, and though an extensive search has been made, not the slightest evidence has been found of the existence of a positive electron of small mass like the negative. In no case has a positive charge been found associated with a mass less than that of the charged atom of hydrogen. This difference between positive and negative electricity is at first sight very surprising, but the deeper we pursue our inquiries the more this fundamental difference between the units of positive and negative electricity is emphasised. In fact, as we shall see later, the atoms are quite unsymmetrical structures with regard to the positive and negative units contained in them, and indeed it seems certain that if there were not this difference in mass between the two units, matter, as we know it, could not exist.

It is natural to inquire what explanation can be given of this striking difference in mass of the two units. I think all scientific men are convinced that the small mass of the negative electron is to be associated entirely with the energy of its electrical structure, so that the electron may be regarded as a disembodied atom of negative electricity. We know that an electron in motion, in addition to possessing an electric field, also generates a magnetic field around it, and energy in the electromagnetic form is stored in the medium and moves with it. This gives the electron an apparent or electrical mass, which, while nearly constant for slow speeds, increases rapidly as its velocity approaches that of light. This increase of mass is in good accord with calculation, whether based on the ordinary electrical theory or on the theory of relativity. Now we know that the hydrogen atom is the lightest of all atoms, and is presumably the simplest in structure, and that the charged hydrogen atom, which we shall see is to be regarded as the hydrogen nucleus, carries a unit positive charge. It is thus natural to suppose that the hydrogen nucleus is the atom of positive electricity, or positive electron, analogous to the negative electron, but differing from it in mass. Electrical theory shows that the mass of a given charge of electricity increases with the concentration, and the greater mass of the hydrogen nucleus would be accounted for if its size were much smaller than that of the electron. Such a conclusion is supported by evidence obtained from the study of the close collisions of α-particles with hydrogen nuclei. It is found that the hydrogen nucleus must be of minute size, of radius less than the electron, which is usually supposed to be about 10^{-13} cm.; also the experimental evidence is not inconsistent with the view that the hydrogen nucleus may actually be much smaller than the electron. While the greater mass of the positive atom of electricity may be explained in this way, we are still left with the enigma why the two units of electricity should differ so markedly in this respect. In the present state of our knowledge it does not seem possible to push this inquiry further, or to discuss the problem of the relation of these two units.

We shall see that there is the strongest evidence that the atoms of matter are built up of these two electrical units, namely the electron and the hydrogen nucleus or proton, as it is usually called when it forms part of the structure of any atom. It is probable that these two are the fundamental and indivisible units which build up our universe, but we may reserve in our mind the possibility that further inquiry may some day show that these units are complex, and divisible into even more fundamental entities. On the views we have outlined, the mass of the atom is the sum of the electrical masses of the individual charged units composing its structure, and there is no need to assume that any other kind of mass exists. At the same time, it is to be borne in mind that the actual mass of an atom may be somewhat less than the sum of the masses of component positive and negative electrons when in the free state. On account of the very close proximity of the charged units in the nucleus of an atom, and the consequent disturbance of the electric and magnetic fields surrounding them, such a decrease of mass is to be anticipated on general theoretical grounds.

We must now look back again to the earlier stages of the present epoch in order to trace the development of our ideas on the detailed structure of the atom. That electrons as such were important constituents was clear by 1900, but little real progress followed until the part played by the positive charges was made clear. New light was thrown on this subject by examining the deviation of α-particles when they passed through the atoms of matter. It was found that occasionally a swift α-particle was deflected from its rectilinear path through more than a right angle by an encounter with a single atom. In such a collision the laws of dynamics ordinarily apply, and the relation between the velocities of the colliding atoms before and after collision are exactly the same as if the two colliding particles are regarded as perfectly elastic spheres of minute dimensions. It must, however, be borne in mind that in these atomic collisions there is no question of mechanical impacts such as we observe with ordinary matter. The reaction between the two particles occurs through the intermediary of the powerful electric fields that surround them. Beautiful photographs illustrating the accuracy of these laws of collision between an α-particle and an atom have been obtained by Messrs. Wilson, Blackett, and others, while Mr. Wilson has recently obtained many striking illustrations of collisions between two electrons. Remembering the great kinetic energy of the α-particle, its deflexion through a large angle in a single atomic encounter shows clearly that very intense deflecting forces exist inside the atom. It seemed clear that electric fields of the required magnitude could be obtained only if the main charge of the atom were concentrated in a minute nucleus. From this arose the conception of the nuclear atom, now so well known, in which the heart of the atom is supposed to consist of a minute but massive nucleus, carrying a positive charge of electricity, and surrounded at a distance by the requisite number of electrons to form a neutral atom.

A detailed study of the scattering of α-particles at different angles, by Geiger and Marsden, showed that the results were in close accord with this theory, and that the intense electric forces near the nucleus varied according to the ordinary inverse square law. In addition, the experiments allowed us to fix an upper limit for the dimensions of the nucleus. For a heavy atom like that of gold the radius of the nucleus, if supposed to be spherical, was less than one-thousandth of the radius of the complete atom surrounded by its electrons, and certainly less than 4×10^{-12} cm. All the atoms were found to show this nuclear structure, and an approximate estimate was made of the nuclear charge of different atoms. This type of nuclear atom, based on direct experimental evidence, possesses some very simple properties. It is obvious that the number of units of resultant positive charge in the nucleus fixes the number of the outer planetary electrons in the neutral atom. In addition, since these outer electrons are in some way held in equilibrium by the attractive forces from the nucleus, and, since we are confident from general physical and chemical evidence that all atoms of any one element are identical in their external structure, it is clear that their arrangement and motion must be governed entirely by the magnitude of the nuclear charge. Since the ordinary chemical and physical properties are to be ascribed mainly to the configuration and motion of the outer electrons, it follows that the properties of an atom are defined by a whole number representing its nuclear charge. It thus becomes of great importance to determine the value of this nuclear charge for the atoms of all the elements.

Data obtained from the scattering of α-particles, and also from the scattering of X-rays by light elements, indicated that the nuclear charge of an element was numerically equal to about half the atomic weight in terms of hydrogen. It was fairly clear from general evidence that the hydrogen nucleus had a charge one, and the helium nucleus (the α-particle) a charge two. At this stage another discovery of great importance provided a powerful method of attack on this problem. The investigation by Laue on the diffraction of X-rays by crystals had shown definitely that X-rays were electromagnetic waves of much shorter wavelength than light, and the experiments of Sir William Bragg and W. L. Bragg had provided simple methods for studying the spectra of a beam of X-rays. It was found that the spectrum in general shows a continuous background on which is superimposed a spectrum of bright lines. At this stage H. G. J. Moseley began a research with the intention of deciding whether the properties of an element depended on its nuclear charge rather than on its atomic weight as ordinarily supposed. For this purpose the X-ray spectra emitted by a number of elements were examined and found to be all similar in type. The frequency of a given line was found to vary very nearly as the square of a whole number which varied by unity in passing from one element to the next. Moseley identified this whole number with the atomic or ordinal number of the elements when arranged in increasing order of atomic weight, allowance being made for the known anomalies in the periodic table and for certain gaps corresponding to possible but missing elements. He concluded that the atomic number of an element was a measure of its nuclear charge, and the correctness of this deduction has been recently verified by Chadwick by direct experiments on the scattering of α-particles. Moseley's discovery is of fundamental importance, for it not only fixes the number of electrons in all the atoms, but also shows conclusively that the properties of an atom, as had been surmised, are determined not by its atomic weight but by its nuclear charge. A relation of unexpected simplicity is thus found to hold between the elements. No one could have anticipated that with few exceptions all atomic numbers between hydrogen 1, and uranium 92, would correspond to known elements. The great power of Moseley's law in fixing the atomic number of an element is well illustrated by the recent discovery by Coster and Hevesy in Copenhagen of the missing element of atomic number 72, which they have named "hafnium."

Once the salient features of the structure of atoms have been fixed and the number of electrons known, the further study of the structure of the atom falls naturally into two great divisions: one, the arrangement of the outer electrons which controls the main physical and chemical properties of an element, and the other, the structure of the nucleus on which the mass and radioactivity of the atom depend. On the nuclear theory the hydrogen atom is of extreme simplicity, consisting of a singly-charged positive nucleus with only one attendant electron. The position and motions of the single electron must account for the complicated optical spectrum, and whatever physical and chemical properties are to be attributed to the hydrogen atom. The first definite attack on the problem of the electronic structure of the atom was made by Niels Bohr. He saw clearly that, if this simple constitution was assumed, it is impossible to account for the spectrum of hydrogen on the classical electrical theories, but that a radical departure from existing views was necessary. For this purpose he applied to the atom the essential ideas of the quantum theory which had been developed by Planck for other purposes, and had been found of great service in explaining many fundamental difficulties in other branches of science. On Planck's theory, radiation is emitted in definite units or quanta, in which the energy E of a radiation is equal to $h\nu$ where ν is the frequency of the radiation measured by the ordinary methods and h a universal constant. This quantum of radiation is not a definite fixed unit like the atom of electricity, for its magnitude depends on the frequency of the radiation. For example, the energy of a quantum is small for visible light, but becomes large for radiation of high frequency corresponding to the X-rays or the γ-rays from radium.

Time does not allow me to discuss the underlying meaning of the quantum theory or the difficulties connected with it. Certain aspects of the difficulties were discussed in the presidential address before this Association by Sir Oliver Lodge at Birmingham in 1913. It suffices to say that this theory has proved of great value in several branches of science, and is supported by a large mass of direct experimental evidence.

In applying the quantum theory to the structure of the hydrogen atom Bohr supposed that the single electron could move in a number of stable orbits, controlled by the attractive force of the nucleus, without losing energy by radiation. The position and character of these orbits were defined by certain quantum relations depending on one or more whole numbers. It was assumed that radiation was only emitted when the electron for some reason was transferred from one stable orbit to another of lower energy. In such a case it was supposed that a homogeneous radiation was emitted of frequency ν determined by the quantum relation $E=h\nu$ where E was the difference of the energy of the electron in the two orbits. Some of these possible orbits are circular, others elliptical, with the nucleus as a focus, while if the change of mass of the electron with velocity is taken into account the orbits, as Sommerfeld showed, depend on two quantum numbers, and are not closed, but consist of a nearly elliptical orbit slowly rotating round the nucleus. In this way it is possible not only to account for the series relations between the bright lines of the hydrogen spectrum, but also to explain the fine structure of the lines and the very complicated changes observed when the radiating atoms are exposed in a strong magnetic or electric field. Under ordinary conditions the electron in the hydrogen atom rotates in a circular orbit close to the nucleus, but if the atoms are excited by an electric discharge or other suitable method, the electron may be displaced and occupy any one of the stable positions specified by the theory. In a radiating gas giving the complete hydrogen spectrum there will be present many different kinds of hydrogen atoms, in each of which the electron describes one of the possible orbits specified by the theory. On this view it is seen that the variety of modes of vibration of the hydrogen atom is ascribed, not to complexity of the structure of the atom, but to the variety of stable orbits which an electron may occupy relative to the nucleus. This novel theory of the origin of spectra has been developed so as to apply not to hydrogen alone but to all the elements, and has been instrumental in throwing a flood of light on the relations and origin of their spectra, both X-ray and optical. The information thus gained has been applied by Bohr to determine the distribution of the electrons round the nucleus of any atom. The problem is obviously much less complicated for hydrogen than for a heavy atom, where each of the large number of electrons present acts on the other, and where the orbits described are much more intricate than the orbit of the single electron in hydrogen. Notwithstanding the great difficulties of such a complicated system of electrons in motion, it has been possible to fix the quantum numbers that characterise the motion of each electron, and to form at any rate a rough idea of the character of the orbit.

These planetary electrons divide themselves up into groups, according as their orbits are characterised by one or more equal quantum numbers. Without going into detail a few examples may be given to illustrate the conclusions which have been reached. As we have seen, the first element, hydrogen, has a nuclear charge of 1 and 1 electron; the second, helium, has a charge 2 and 2 electrons, moving in coupled orbits on the detailed nature of which there is still some uncertainty. These two electrons form a definite group, known as the K group, which is common to all the elements except hydrogen. For increasing nuclear charge the K group of electrons retains its characteristics, but moves with increasing speed, and approaches closer to the nucleus. As we pass from helium of atomic number 2 to neon, number 10, a new group of electrons is added consisting of two sub-groups, each of four electrons, together called the L group. This L group appears in all atoms of higher atomic number, and, as in the case of the K group, the speed of motion of the electrons increases, and the size of their orbits diminishes with the atomic number. When once the L group has been completed a new and still more complicated M group of electrons begins forming outside it, and a similar process goes on until uranium, which has the highest atomic number, is reached.

It may be of interest to try to visualise the conception of the atom we have so far reached by taking for illustration the heaviest atom, uranium. At the centre of the atom is a minute nucleus surrounded by a swirling group of 92 electrons, all in motion in definite orbits, and occupying but by no means filling a volume very large compared with that of the nucleus. Some of the electrons describe nearly circular orbits round the nucleus; others, orbits of a more elliptical shape with axes rotating rapidly round the nucleus. The motion of the electrons in the different groups is not necessarily confined to a definite region of the atom, but the electrons of one group may penetrate deeply into the region mainly occupied by another group, thus giving a type of inter-connexion or coupling between the various groups. The maximum speed of any electron depends on the closeness of the approach to the nucleus, but the outermost electron will have a minimum speed of more than 1000 kilometres per second, while the innermost K electrons have an average speed of more than 150,000 kilometres per second, or half the speed of light. When we visualise the extraordinary complexity of the electronic system we may be surprised that it has been possible to find any order in the apparent medley of motions.

In reaching these conclusions, which we owe largely to Prof. Bohr and his co-workers, every available kind of data about the different atoms has been taken into consideration. A study of the X-ray spectra, in particular, affords information of great value as to the arrangement of the various groups in the atom, while the optical spectrum and general chemical properties are of great importance in deciding the arrangements of the superficial electrons. While the solution of the grouping of the electrons proposed by Bohr has been assisted by considerations of this kind, it is not empirical in character, but has been largely based on general theoretical considerations of the orbits of electrons that are physically possible on the generalised quantum theory. The real problem involved may be illustrated in the following way. Suppose the gold nucleus be in some way stripped of its attendant seventy-nine electrons and that the atom is reconstituted by the successive addition of electrons one by one. According to Bohr, the atom will be reorganised in one way only, and one group after another will successively form and be filled up in the manner outlined. The nucleus atom has often been likened to a solar system where the sun corresponds to the nucleus and the planets to the electrons. The analogy, however, must not be pressed too far. Suppose, for example, we imagined that some large and swift celestial visitor traverses and escapes from our solar system without any catastrophe to itself or the planets. There will inevitably result permanent changes in the lengths of the month and year, and our system will never return to its original state. Contrast this with the effect of shooting an electron or α-particle through the electronic structure of the atom. The motion of many of the electrons will be disturbed by its passage, and in special cases an electron may be removed from its orbit and hurled out of its atomic system. In a short time another electron will fall into the vacant place from one of the outer groups, and this vacant place in turn will be filled up, and so on until the atom is again reorganised. In all cases the final state of the electronic system is the same as in the beginning. This illustration also serves to indicate the origin of the X-rays excited in the atom, for these arise in the process of re-formation of an atom from which an electron has been ejected, and the radiation of highest frequency arises when the electron is removed from the K group.

It is possibly too soon to express a final opinion on the accuracy of this theory which defines the outer structure of the atom, but there can be no doubt that it constitutes a great advance. Not only does it offer a general explanation of the optical and X-ray spectra of the atom, but it accounts in detail for many of the most characteristic features of the periodic law of Mendeléeff. It gives us for the first time a clear idea of the reason for the appearance in the family of elements of groups of consecutive elements with similar chemical properties, such as the groups analogous to the iron group and the unique group of rare earths. The theory of Bohr, like all living theories, has not only correlated a multitude of isolated facts known about the atom, but has shown its power to predict new relations which can be verified by experiment. For example, the theory predicted the relations which must subsist between the Rydberg constants of the arc and spark spectra, and generally between all the successive optical spectra of an element, a prediction so strikingly confirmed by Paschen's work on the spectrum of doubly ionised aluminium and Fowler's work on the spectrum of trebly ionised silicon. Finally, it predicted with such great confidence the chemical properties of the missing element, number 72, that it gave the necessary incentive for its recent discovery.

While the progress of our knowledge of the outer structure of atoms has been much more rapid than could have been anticipated, we clearly see that only a beginning has been made on this great problem, and that an enormous amount of work is still required before we can hope to form anything like a complete picture even of the outer structure of the atom. We may be confident that the main features of the structure are clear, but in a problem of such great complexity progress in detail must of necessity be difficult and slow.

We have not so far referred to the very difficult question of the explanation on this theory of the chemical combination of atoms. In fact, as yet the theory has scarcely concerned itself with molecular structure. On the chemical side, however, certain advances have already been made, notably by G. N. Lewis, Kossel, and Langmuir, in the interpretation of the chemical evidence by the idea of shared electrons, which play a part in the electronic structure of two combined atoms. There can be little doubt that the next decade will see an intensified attack by physicists and chemists on this very important but undoubtedly very complicated question.

Before leaving this subject, it may be of interest to refer to certain points in Bohr's theory of a more philosophical nature. It is seen that the orbits and energies of the various groups of electrons can be specified by certain quantum numbers, and the nature of the radiation associated with a change of orbit can be defined. But at the same time we cannot explain why these orbits are alone permissible under normal conditions, or understand the mechanism by which radiation is emitted. It may be quite possible to formulate accurately the energy relation of the electrons in the atom on a simple theory, and to explain in considerable detail all the properties of an atom, without any clear understanding of the underlying processes which lead to these results. It is natural to hope that with advance of knowledge we may be able to grasp the details of the process which leads to the emission of radiation, and to understand why the orbits of the electrons in the atom are defined by the quantum relations. Some, however, are inclined to take the view that in the present state of knowledge it may be quite impossible in the nature of things to form that detailed picture in space and time of successive events that we have been accustomed to consider as so important a part of a complete theory. The atom is naturally the most fundamental structure presented to us. Its properties must explain the properties of all more complicated structures, including matter in bulk, but we may not, therefore, be justified in expecting that its processes can be explained in terms of concepts derived entirely from a study of molar properties. The atomic processes involved may be so fundamental that a complete understanding may be denied us. It is early yet to be pessimistic on this question, for we may hope that our difficulties may any day be resolved by further discoveries.

We must now turn our attention to that new and comparatively unexplored territory, the nucleus of the atom. In a discussion on the structure of the atom ten years ago, in answer to a question on the structure of the nucleus, I was rash enough to say that it was a problem that might well be left to the next generation, for at that time there seemed to be few obvious methods of attack to throw light on its constitution. While much more progress has been made than appeared possible at that time, the problem of the structure of the nucleus is inherently more difficult than the allied problem already considered of the structure of the outer atom, where we have a wealth of information obtained from the study of light and X-ray spectra and from the chemical properties to test the accuracy of our theories.

In the case of the nucleus, we know its resultant charge, fixed by Moseley's law, and its mass, which is very nearly equal to the mass of the whole atom, since the mass of the planetary electrons is relatively very small and may for most purposes be neglected. We know that the nucleus is of size minute compared with that of the whole atom, and can with some confidence set a maximum limit to its size. The study of radioactive bodies has provided us with very valuable information on the structure of the nucleus, for we know that the α- and β-particles must be expelled from it, and there is strong evidence that the very penetrating γ-rays represent modes of vibration of the electrons contained in its structure. In the long series of transformations which occur in the uranium atom, eight α-particles are emitted and six electrons, and it seems clear that the nucleus of a heavy atom is built up, in part at least, of helium nuclei and electrons. It is natural to suppose that many of the ordinary stable atoms are constituted in a similar way. It is a matter of remark that no indication has been obtained that the lightest nucleus, namely, that of hydrogen, is liberated in these transformations, where the processes occurring are of so fundamental a character. At the same time, it is evident that the hydrogen nucleus must be a unit in the structure of some atoms, and this has been confirmed by direct experiment. Dr. Chadwick and I have observed that swift hydrogen nuclei are released from the elements boron, nitrogen, fluorine, sodium, aluminium, and phosphorus when they are bombarded by swift α-particles, and there is little room for doubt that these hydrogen nuclei form an essential part of the nuclear structure. The speed of ejection of these nuclei depends on the velocity of the α-particle and on the element bombarded. It is of interest to note that the hydrogen nuclei are liberated in all directions, but the speed in the backward direction is always somewhat less than in the direction of the α-particle. Such a result receives a simple explanation if we suppose that the hydrogen nuclei are not built into the main nucleus but exist as satellites probably in motion round a central core. There can be no doubt that bombardment by α-particles has effected a veritable disintegration of the nuclei of this group of elements. It is significant that the liberation of hydrogen nuclei only occurs in elements of odd atomic number, namely, 5, 7, 9, 11, 13, 15, the elements of even number appearing quite unaffected. For a collision of an α-particle to be effective, it must either pass close to the nucleus or actually penetrate its structure. The chance of this is excessively small on account of the minute size of the nucleus. For example, although each individual α-particle will pass through the outer structure of more than 100,000 atoms of aluminium in its path, it is only about one α-particle in a million that gets close enough to the nucleus to effect the liberation of its hydrogen satellite.

This artificial disintegration of elements by α-particles takes place only on a minute scale, and its observation has only been possible by the counting of individual swift hydrogen nuclei by the scintillations they produce in zinc sulphide.

These experiments suggest that the hydrogen nucleus or proton must be one of the fundamental units which build up a nucleus, and it seems highly probable that the helium nucleus is a secondary building unit composed of the very close union of four protons and two electrons. The view that the nuclei of all atoms are ultimately built up of protons of mass nearly one and of electrons has been strongly supported and extended by the study of isotopes. It was early observed that some of the radioactive elements which showed distinct radioactive properties were chemically so alike that it was impossible to effect their separation when mixed together. Similar elements of this kind were called "isotopes" by Soddy, since they appeared to occupy the same place in the periodic table. For example, a number of radioactive elements in the uranium and thorium series have been found to have physical and chemical properties identical with those of ordinary lead, but yet to have atomic weights differing from ordinary lead, and also distinctive radioactive properties. The nuclear theory of the atom offers at once a simple interpretation of the relation between isotopic elements. Since the chemical properties of an element are controlled by its nuclear charge and little influenced by its mass, isotopes must correspond to atoms with the same nuclear charge but of different nuclear mass. Such a view also offers a simple explanation why the radioactive isotopes show different radioactive properties, for it is to be anticipated that the stability of a nucleus will be much influenced by its mass and arrangement.

Our knowledge of isotopes has been widely extended in the last few years by Aston, who has devised an accurate direct method for showing the presence of isotopes in the ordinary elements. He has found that some of the elements are "pure"—*i.e.* consist of atoms of identical mass—while others contain a mixture of two or more isotopes. In the case of the isotopic elements, the atomic mass, as ordinarily measured by the chemist, is a mean value depending on the atomic masses of the individual isotopes and their relative abundance. These investigations have not only shown clearly that the number of distinct species of atoms is much greater than was supposed, but have also brought out a relation between the elements of great interest and importance. The atomic masses of the isotopes of most of the elements examined have been found, to an accuracy of about one in a thousand, to be whole numbers in terms of oxygen, 16. This indicates that the nuclei are ultimately built up of protons of mass very nearly 1 and of electrons. It is natural to suppose that this building unit is the hydrogen nucleus, but that its average mass in the complex nucleus is somewhat less than its mass in the free state owing to the close packing of the charged units in the nuclear structure. We have already seen that the helium nucleus of mass 4 is probably a secondary unit of great importance in the building up of many atoms, and it may be that other simple combinations of protons and electrons of mass 2 and 3 occur in the nucleus, but these have not been observed in the free state.

While the mass of the majority of the isotopes are nearly whole numbers, certain cases have been observed by Aston where this rule is slightly departed from. Such variations in mass may ultimately prove of great importance in throwing light on the arrangement and closeness of packing of the protons and electrons, and for this reason it is to be hoped that it may soon prove possible to compare atomic masses of the elements with much greater precision even than at present.

While we may be confident that the proton and the electron are the ultimate units which take part in the building up of all nuclei, and can deduce with some certainty the number of protons and electrons in the nuclei of all atoms, we have little, if any, information on the distribution of these units in the atom or on the nature of the forces that hold them in equilibrium. While it is known that the law of the inverse square holds for the electrical forces some distance from the nucleus, it seems certain that this law breaks down inside the nucleus. A detailed study of the collisions between α-particles and hydrogen atoms, where the nuclei approach very close to each other, shows that the forces between nuclei increase ultimately much more rapidly than is to be expected from the law of the inverse square, and it may be that new and unexpected forces may come into importance at the very small distances separating the protons and electrons in the nucleus. Until we gain more information on the nature and law of variation of the forces inside the nucleus, further progress on the detailed structure of the nucleus may be difficult. At the same time, there are still a number of hopeful directions in which an attack may be made on this most difficult of problems. A detailed study of the γ-rays from radioactive bodies may be expected to yield information as to the motion of the electrons inside the nucleus, and it may be, as Ellis has suggested, that quantum laws are operative inside as well as outside the nucleus. From a study of the relative proportions of the elements in the earth's crust, Harkins has shown that elements of even atomic number are much more abundant than elements of odd number, suggesting a marked difference of stability in these two classes of elements. It seems probable that any process of stellar evolution must be intimately connected with the building up of complex nuclei from simpler ones, and its study may thus be expected to throw much light on the evolution of the elements.

The nucleus of a heavy atom is undoubtedly a very complicated system, and in a sense a world of its own, little, if at all, influenced by the ordinary physical and chemical agencies at our command. When we consider the mass of a nucleus compared with its volume it seems certain that its density is many billions of times that of our heaviest element. Yet, if we could form a magnified picture of the nucleus, we should expect that it would show a discontinuous structure, occupied but not filled by the minute building units, the protons and electrons, in ceaseless rapid motion controlled by their mutual forces.

Before leaving this subject it is desirable to say a few words on the important question of the energy relations involved in the formation and disintegration of atomic nuclei, first opened up by the study of radioactivity. For example, it is well known that the total evolution of energy during the complete disintegration of one gram of radium is many millions of times greater than in the complete combustion of an equal weight of coal. It is known that this energy is initially mostly emitted in the kinetic form of swift α- and β-particles, and the energy of motion of these bodies is ultimately converted into heat when they are stopped by matter. Since it is believed that the radioactive elements are analogous in structure to the ordinary inactive elements, the idea naturally arose that the atoms of all the elements contained a similar concentration of energy, which would be available for use if only some simple method could be discovered of promoting and controlling their disintegration. This possibility of obtaining new and cheap sources of energy for practical purposes was naturally an alluring prospect to the lay and scientific man alike. It is quite true that, if we were able to hasten the radioactive processes in uranium and thorium so that the whole cycle of their disintegration could be confined to a few days instead of being spread over thousands of millions of years, these elements would provide very convenient sources of energy on a sufficient scale to be of considerable practical importance. Unfortunately, although many experiments have been tried, there is no evidence that the rate of disintegration of these elements can be altered in the slightest degree by the most powerful laboratory agencies. With increase in our knowledge of atomic structure there has been a gradual change of our point of view on this important question, and there is by no means the same certainty to-day as a decade ago that the atoms of an element contain hidden stores of energy. It may be worth while to spend a few minutes in discussing the reason for this change in outlook. This can best be illustrated by considering an interesting analogy between the transformation of a radioactive nucleus and the changes in the electron arrangement of an ordinary atom. It is now well known that it is possible by means of electron bombardment or by appropriate radiation to excite an atom in such a way that one of its superficial electrons is displaced from its ordinary stable position to another temporarily stable position further removed from the nucleus. This electron in course of time falls back into its old position, and its potential energy is converted into radiation in the process. There is some reason for believing that the electron has a definite average life in the displaced position, and that the chance of its return to its original position is governed by the laws of probability. In some respects an "excited" atom of this kind is thus analogous to a radioactive atom, but of course the energy released in the disintegration of a nucleus is of an entirely different order of magnitude from the energy released by return of the electron in the excited atom. It may be that the elements, uranium and thorium, represent the sole survivals in the earth to-day of types of elements that were common in the long-distant ages, when the atoms now composing the earth were in course of formation. A fraction of the atoms of uranium and thorium formed at that time has survived over the long interval on account of their very slow rate of transformation. It is thus possible to regard these atoms as having not yet completed the cycle of changes which the ordinary atoms have long since passed through, and that the atoms are still in the "excited" state where the nuclear units have not yet arranged themselves in positions of ultimate equilibrium, but still have a surplus of energy which can only be released in the form of the characteristic radiation from active matter. On such a view, the presence of a store of energy ready for release is not a property of all atoms, but only of a special class of atoms like the radioactive atoms which have not yet reached the final state for equilibrium.

It may be urged that the artificial disintegration of certain elements by bombardment with swift α-particles gives definite evidence of a store of energy in some of the ordinary elements, for it is known that a few of the hydrogen nuclei, released from aluminium for example, are expelled with such swiftness that the particle has a greater individual energy than the α-particle which causes their liberation. Unfortunately, it is very difficult to give a definite answer on this point until we know more of the details of this disintegration.

On the other hand, another method of attack on this question has become important during the last few years, based on the comparison of the relative masses of the elements. This new point of view can best be illustrated by a comparison of the atomic masses of hydrogen and helium. As we have seen, it seems very probable that helium is not an ultimate unit in the structure of nuclei, but is a very close combination of four hydrogen nuclei and two electrons. The mass of the helium nucleus, 4·00 in terms of $O=16$, is considerably less than the mass, 4·03, of four hydrogen nuclei. On modern views there is believed to be a very close connexion between mass and energy, and this loss in mass in the synthesis of the helium nucleus from hydrogen nuclei indicates that a large amount of energy in the form of radiation has been released in the building of the helium nucleus from its components. It is easy to calculate from this loss of mass that the energy set free in forming one gram of helium is large even compared with that liberated in the total disintegration of one gram of radium. For example, calculation shows that the energy released in the formation of one pound of helium gas is equivalent to the energy emitted in the complete combustion of about eight thousand tons of pure carbon. It has been suggested by Eddington and Perrin that it is mainly to this source of energy that we must look to maintain the heat emission of the sun and hot stars over long periods of time. Calculations of the loss of heat from the sun show that this synthesis of helium need only take place slowly in order to maintain the present rate of radiation for periods of the order of one thousand million years. It must be acknowledged that these arguments are somewhat speculative in character, for no certain experimental evidence has yet been obtained that helium can be formed from hydrogen.

The evidence of the slow rate of stellar evolution, however, certainly indicates that the synthesis of helium, and perhaps other elements of higher atomic weight, may take place slowly in the interior of hot stars. While in the electric discharge through hydrogen at low pressure we can easily reproduce the conditions of the interior of the hottest star so far as regards the energy of motion of the electrons and hydrogen nuclei, we cannot hope to reproduce that enormous density of radiation which must exist in the interior of a giant star. For this and other reasons it may be very difficult, or even impossible, to produce helium from hydrogen under laboratory conditions.

If this view of the great heat emission in the formation of helium be correct, it is clear that the helium nucleus is the most stable of all nuclei, for an amount of energy corresponding to three or four α-particles would be required to disrupt it into its components. In addition, since the mass of the proton in nuclei is nearly 1·000 instead of its mass 1·0072 in the free state, it follows that much more energy must be put into the atom than will be liberated by its disintegration into its ultimate units. At the same time, if we consider an atom of oxygen, which may be supposed to be built up of four helium nuclei as secondary units, the change of mass, if any, in its synthesis from already formed helium nuclei is so small that we cannot yet be certain whether there will be a gain or loss of energy by its disintegration into helium nuclei, but in any case we are certain that the magnitude of the energy will be much less than for the synthesis of helium from hydrogen. Our information on this subject of energy changes in the formation or disintegration of atoms in general is as yet too uncertain and speculative to give any decided opinion on future possibilities in this direction, but I have endeavoured to outline some of the main arguments which should be taken into account.

I must now bring to an end my survey, I am afraid all too brief and inadequate, of this great period of advance in physical science. In the short time at my disposal it has been impossible for me, even if I had the knowledge, to refer to the great advances made during the period under consideration in all branches of pure and applied science. I am well aware that in some departments the progress made may justly compare with that of my own subject. In these great additions to our knowledge of the structure of matter every civilised nation has taken an active part, but we may be justly proud that Great Britain has made many fundamental contributions. With this country I must properly include the Dominions overseas, for they have not been behindhand in their contributions to this new knowledge. It is, I am sure, a matter of pride to this country that the scientific men of the Dominions have been responsible for some of the most fundamental discoveries of this epoch, particularly in radioactivity.

This tide of advance was continuous from 1896, but there was an inevitable slackening during the War. It is a matter of good omen that, in the last few years, the old rate of progress has not only been maintained but even intensified, and there appears to be no obvious sign that this period of great advances has come to an end. There has never been a time when the enthusiasm of the scientific workers was greater, or when there was a more hopeful feeling that great advances were imminent. This feeling is no doubt in part due to the great improvement during this epoch of the technical methods of attack, for problems that at one time seemed unattackable are now seen to be likely to fall before the new methods. In the main, the epoch under consideration has been an age of experiment, where the experimenter has been the pioneer in the attack on new problems. At the same time, it has been also an age of bold ideas in theory, as the quantum theory and the theory of relativity so well illustrate.

I feel it is a great privilege to have witnessed this period, which may almost be termed the renaissance of physics. It has been of extraordinary intellectual interest to watch the gradual unfolding of new ideas and the ever-changing methods of attack on difficult problems. It has been of great interest, too, to note the comparative simplicity of the ideas that have ultimately emerged. For example, no one could have anticipated that the general relation between the elements would prove to be of so simple a character as we now believe it to be. It is an illustration of the fact that Nature appears to work in a simple way, and that the more fundamental the problem, often the simpler are the conceptions needed for its explanation. The rapidity and certitude of the advance in this epoch have largely depended on the fact that it has been possible to devise experiments so that few variables were involved. For example, the study of the structure of the atom has been much facilitated by the possibility of examining the effects due to a single atom of matter, or, as in radioactivity or X-rays, of studying processes going on in the individual atom which were quite uninfluenced by external conditions.

In watching the rapidity of this tide of advance in physics I have become more and more impressed by the power of the scientific method of extending our knowledge of Nature. Experiment, directed by the disciplined imagination either of an individual, or still better, of a group of individuals of varied mental outlook, is able to achieve results which far transcend the imagination alone of the greatest natural philosopher. Experiment without imagination, or imagination without recourse to experiment, can accomplish little, but, for effective progress, a happy blend of these two powers is necessary. The unknown appears as a dense mist before the eyes of men. In penetrating this obscurity we cannot invoke the aid of supermen, but must depend on the combined efforts of a number of adequately trained ordinary men of scientific imagination. Each in his own special field of inquiry is enabled by the scientific method to penetrate a short distance, and his work reacts upon and influences the whole body of other workers. From time to time there arises an illuminating conception, based on accumulated knowledge, which lights up a large region and shows the connexion between these individual efforts so that a general advance follows. The attack begins anew on a wider front, and often with improved technical weapons. The conception which led to this advance often appears simple and obvious when once it has been put forward. This is a common experience, and the scientific man often feels a sense of disappointment that he himself had not foreseen a development which ultimately seems so clear and inevitable.

The intellectual interest due to the rapid growth of science to-day cannot fail to act as a stimulus to young men to join in scientific investigation. In every branch of science there are numerous problems of fundamental interest and importance which await solution. We may confidently predict an accelerated rate of progress of scientific discovery, beneficial to mankind certainly in a material, but possibly even more so in an intellectual sense. In order to obtain the best results, certain conditions must, however, be fulfilled. It is necessary that our universities and other specific institutions should be liberally supported, so as not only to be in a position to train adequately young investigators of promise, but also to serve themselves as active centres of research. At the same time there must be a reasonable competence for those who have shown a capacity for original investigation. Not least, peace throughout the civilised world is as important for rapid scientific development as for general commercial prosperity. Indeed, science is truly international, and for progress in many directions the co-operation of nations is as essential as the co-operation of individuals. Science, no less than industry, desires a stability not yet achieved in world conditions.

There is an error far too prevalent to-day that science progresses by the demolition of former well-established theories. Such is very rarely the case. For example, it is often stated that Einstein's general theory of relativity has overthrown the work of Newton on gravitation. No statement could be further from the truth. Their works, in fact, are scarcely comparable, for they deal with different fields of thought. So far as the work of Einstein is relevant to that of Newton, it is simply a generalisation and broadening of its basis; in fact, a typical case of mathematical and physical development. In general, a great principle is not discarded, but so modified that it rests on a broader and more stable basis.

It is clear that the splendid period of scientific activity which we have here reviewed owes much of its success and intellectual appeal to the labours of those great men in the past, who wisely laid the sure foundations on which the scientific worker builds to-day, or to quote from the words inscribed in the dome of the National Gallery, "The works of those who have stood the test of ages have a claim to that respect and veneration to which no modern can pretend."

Scientific Problems and Progress.[1]

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS OF THE BRITISH ASSOCIATION.

THE ORIGIN OF SPECTRA.

THE focus of Prof. McLennan's remarks in his presidential address to Section A (Mathematics and Physics), to be delivered on September 17, is Bohr's theory of the origin of radiation and of atomic structure. Evidence in support of the theory is drawn largely from recent researches on the spectra of the elements.

Among the subjects discussed are the significance of the fine structure of the spectral lines of hydrogen and the recent attempts to devise a model of the helium atom capable of accounting for the characteristics of the helium spectrum.

In dealing with the question of the genesis of atoms of various types, illustrations are given of the view recently put forward by Bohr that the fundamental process that must apply consists in the successive binding of electrons by a nucleus originally naked. Bohr's scheme of electronic orbits for the atoms of different elements provides a means of establishing a connexion between spectral series formulæ of different types and the energy levels in atoms and, also, of deducing the values of resonance and ionisation potentials, hitherto undetermined, for a number of elements. Special attention is paid to the elements of the lead-tin and chromium-manganese groups.

A number of illustrations are given of the Kossel-Sommerfeld Displacement Law, and the importance of the recent work of Fowler and of Paschen in this connexion is emphasised. Spectroscopic data, recently obtained, that are likely to lead to extensions of this work are also discussed.

In dealing with the magnetic properties of certain contiguous elements, anomalies are referred to that apparently do not find so ready an explanation with Bohr's scheme of electronic orbits for the atoms of successive elements as the Kossel-Sommerfeld Displacement Law. Reference is also made to the principle of quantisation in space recently brought into prominence by the interesting experiments of Gerlach and Stern and by the work of R. W. Wood and Ellett.

[1] All the presidential addresses are published in full in "The Advancement of Science: 1923" (London: John Murray).

This latter, it will be recalled, deals with the power possessed by weak magnetic fields of modifying the capability shown by the vapours of mercury and sodium of polarising radiation scattered by them.

The adiabatic hypothesis enunciated by Ehrenfest is discussed, and also the use of this principle in conjunction with the quantum theory in elucidating Zeeman effects of the normal type. Reference is made, as well, to the interesting and suggestive attempts of Heisenberg and Sommerfeld to find in a development of the quantum theory an explanation of the anomalous Zeeman effect exhibited by certain classes of spectral lines. In this application of the quantum theory it is assumed that the doublet separations characteristic of series such as those of the arc spectra of the alkali elements are in reality Zeeman separations produced by intra-atomic magnetic fields. In conclusion there are illustrations of the magnitude of such intra-atomic magnetic fields, and a discussion of some of the difficulties raised by Heisenberg and Sommerfeld's theory and of some objections in the way of its immediate and general acceptance.

Physical Chemistry of Surfaces.

The subjects dealt with by Prof. F. G. Donnan, in his address to Section B (Chemistry) are principally molecular orientation and molecular dimensions at surfaces and in surface films, molecular concentration at surfaces and its effect on surface tension, electrical potential differences at surfaces, stabilities of foams, oil suspensions, lyophobic hydrosols, and oil emulsions. The surfaces especially considered are the liquid-gas and liquid-liquid surfaces. The researches of W. B. Hardy have led to the conception of surface layers of oriented molecules, as the result of unsymmetrical fields of force surrounding molecules, due to the presence of active atoms or atomic groups. The views of Hardy have been confirmed by the work of W. D. Harkins and his collaborators.

The study of *unimolecular* surface layers of insoluble substances on the surface of water, initiated by the late Lord Rayleigh and developed by H. Devaux and A. Marcelin, has led in the hands of I. Langmuir and N. K. Adam to the determination of molecular and atomic dimensions. Certain recent investigations by X-ray methods have an interesting bearing on these results.

Unimolecular layers may also be formed by the adsorption of vapours on liquid and solid surfaces. Dissolved substances which lower the surface tension of a gas-liquid or liquid-liquid interface concentrate at these interfaces. Do they form unimolecular layers ?

Electric potential differences exist at the gas-liquid, liquid-liquid, and solid-liquid interfaces. These potential differences are affected by "surface-active" substances, by ions, colloidal micelles, etc. The potential differences determine the stabilities of oil suspensions and lyophobic hydrosols. The "critical" potential differences and the "critical zone" of potential difference are of importance in such cases.

The formation of concentrated surface layers and surface films plays an important rôle in the production and stabilisation of emulsions. Surface actions are of importance in biological phenomena. The existence and activity of the living organism are dynamic and depend on an environment which is not in equilibrium. The living organism is an *individual.* Further progress will depend on the study of the particular actions of individuals rather than the average behaviour of "crowds."

Evolutional Palæontology.

The presidential address by Dr. Gertrude Elles to Section C (Geology) is on the subject of "Evolutional Palæontology in Relation to the Lower Palæozoic Rocks." The problems of the Lower Palæozoic Rocks still awaiting solution are in the main those of classification and structure, which are largely interdependent. The most satisfactory solution appears to lie in the application of the principles of evolutional palæontology. The most effective modern classification of strata is that based upon the coming in of new forms of life, but if it is to be of wide application this must not be connected directly with changes in the character of the sedimentation.

The variation in the nature of shallow-water faunas due to various factors such as temperature, salinity, and clearness of the water, is illustrated by reference to the recent work at the Danish Biological Station; the classification and correlation of such deposits must be a matter of great difficulty unless a common principle can be introduced. The standard for purposes of classification must be sought in the faunas of the deeper waters of the Lower Palæozoic seas, where the changes in the fauna show primarily as an advance in the evolutional stage of the organisms concerned. The various shallow-water deposits should be referred to those of deeper-water origin when possible, or the relative ages may to some extent be determined by noting the evolutional stage reached by various organisms composing the faunas.

These principles are illustrated by a study of the evolution of the Graptoloidea as the characteristic fauna of the deeper-water sediments of the Lower Palæozoic, and it is shown that important evolutional stages are characteristic of definite geological horizons, these being recognisable without any knowledge of the various Graptolite species. In the faunas of the shallower-waters the evolution of certain features in some species-groups of the Trilobita are described and the horizons at which these occur are noted. Mention is made of the work already published on other fossil phyla, and attention is especially directed to that of various observers on the evolution of the corals in the Carboniferous as the type of work to be aimed at in the future in the Lower Palæozoic Rocks.

The old purely descriptive work so often carried out entirely in the museum or laboratory must give place to that in which fossils are regarded as parts of once-living entities possessing definite ancestors and descendants developing along definite lines, the relationships of these being controlled always by field work.

Zoology and its Human Aspects.

Prof. Ashworth devoted the first part of his address to Section D (Zoology), on September 13, to a brief retrospective glance over some of the lines of development in zoology since the last meeting in

Liverpool. He referred to the rapid extension of physiological methods of inquiry to the lower organisms, the discovery of artificial parthenogenesis, the intensive study of egg-cleavage, cell-lineage, and the maturation of the egg and sperm, the remarkable progress of cytology, and to researches on the structural basis of heredity and on the nuclear mechanism correlated with sex. Other subjects discussed were the study of the finer structure of the nerve-cell and its processes and of the neuromotor system of the Protozoa, the investigations on the ciliate Protozoa, especially on Paramæcium, with the purpose of ascertaining whether decline and death depend on inherent factors or on external conditions, and the researches on the culture of tissues, which are leading to a knowledge of the conditions which determine the growth and differentiation of somatic cells.

In the second part of the address some of the bearings of zoology on human welfare were considered. At the time of the last meeting in Liverpool insects were suspected of acting as transmitters of certain pathogenic organisms to man, but these cases were few and in no single instance had the life-cycle of the organism been worked out and the mode of transmission from insect to man ascertained. The part played by the mosquito as host and transmitter of the parasite of malaria was made known by Ross nearly two years after that meeting. Of the ten important examples of arthropods now proved to act as carriers of pathogenic organisms to man, Prof. Ashworth chose three for consideration, namely, Stegomyia and yellow fever, tsetse-flies and sleeping-sickness, and the flea *Xenopsylla cheopis* and plague, this last providing a fine illustration of the value of careful work on the systematics and on the structure and bionomics of the insect concerned. Intensive work on the Protozoa has been an outstanding feature during the last twenty-five years, and *Entamœba histolytica*, the organism of amœbic dysentery, was taken as an example of the importance of researches on Protozoa which directly affect man. Of the notable investigations on parasitic worms, reference was made to the great advances in our knowledge of the life-history and bionomics of Ancylostoma and of Schistosoma (Bilharzia), which have enabled effective measures to be taken against infection by these parasites.

In conclusion, Prof. Ashworth referred to the place and value of zoology in the medical curriculum, gave an outline of the subjects which he considered should be included in the course of zoology for medical students, and invited discussion on this part of the address.

The British Empire as a Maritime State.

The subject of Dr. Vaughan Cornish's presidential address to Section E (Geography) is the "Geographical Position of the British Empire." It may be thought that an Empire on which the sun never sets, with lands in both hemispheres and on every continent, cannot be assigned a place upon the map, and in fact so long as it is regarded from the continental point of view it cannot be given a definite geographical position. It is, however, a maritime State, the metropolitan and other provinces being united by ocean routes on which lie British ports of call which can be used as naval stations, but separated strategically by those parts of the ocean which are not so provided, and are readily dominated from the ports of other Great Powers. An examination of these conditions shows that, taking account only of the communications which are available in all circumstances, the lands of the British Empire are connected by the Atlantic and Indian, separated by the North Pacific Ocean. Hence the geographical position of the Empire is well represented by the form of Mercator map in which the meridian of Greenwich is central and the right- and left-hand edges are at longitude 180°. The Empire thus appears astride the North Atlantic and the Indian Ocean, but with its Pacific shores unconnected.

A symmetrical arrangement is revealed upon this map if a direct line (part of a great circle) be drawn from Halifax, Nova Scotia, the eastern terminal of the Canadian Pacific Railway, to Fremantle, the western terminal port of the Australian railways. This direct line (twisted on the map into the form of the letter S) passes through Lower Egypt close to the Suez Canal, which is not very far from its middle point. It follows somewhat closely the main steamship track of the Empire. At one end is Canada, at the other Australasia, the British Isles on the north and South Africa on the south. The coloured populations of the Empire are also distributed symmetrically with reference to the line, those of India on the east, of Africa on the west, so that the great circle from Halifax, N.S., eastwards to Fremantle is the geometrical axis of the Empire.

The Empire as thus mapped can be shown to have an intermediate position on the present commercial and international communications of the world such as no other Great Power occupies, so that the British, in a greater degree than any other people, are the doorkeepers of the world.

The consolidation of the position turns on the future of colonisation during the time which remains before the untilled lands of the world are occupied by peasantry. In the second part of the address the present tendency of this movement is traced both among coloured and white peoples, and special attention is given to the question, now so much debated, whether a surplus of birth-rate over death-rate in Great Britain is, or is not, in the interests of the country, of the peoples of the Empire, and of mankind.

Population and Unemployment.

The common impression that Europe is already threatened with over-population may be traced to two sources—to observation of the exceptional volume of unemployment to-day, and to the words of certain economists describing Europe before the War. Sir William Beveridge deals with these subjects in his presidential address to be given to Section F (Economics) on Monday, September 17. Unemployment does not necessarily or naturally point to excessive growth of population; severe and prolonged unemployment has occurred at times and in countries which were certainly not marked by over-population. Statements such as those of Mr. Keynes, that Europe was over-populated even before the War, appear ill-founded; in Europe, no less than in the New World, the yield of corn per acre and per head of the population was rising, not falling; the price of corn relatively to other commodities was falling, not rising, up to the eve of War. There is still room for the expansion of the white races. In Britain, as distinct from Europe as a whole, the rate of material progress which marked the Victorian age was not maintained from 1900 to 1910; this apparent check, however, may have been temporary and due to special causes.

In considering the position of Britain after the War, the example of German Austria, a highly specialised and advanced community depending on free trade over a large and varied area, is apposite. The optimum density of population in any given region depends, not on that region alone, but also on the economic conditions and needs of the rest of the world. A decline of international dealing hurts all, but most of all the highly specialised communities typified by German Austria and Britain. The suggestion that we should avoid the "Austrian risk" in future by aiming at self-sufficiency is not practical. Britain, as we know it, and with anything like its present population, depends upon peace and trade. Its excessive unemployment to-day can be fully explained by the War and its aftermath of economic disorganisation, and the remedy must be sought elsewhere than in birth control.

Though, however, increased birth control is not required by the conditions of Europe before the War and is irrelevant to its present troubles, the problem of numbers has to be faced. Man cannot with safety indefinitely reduce the death-rate and leave the birth-rate to look after itself; as a matter of history, he has at almost all stages of his development limited the number of his descendants. The problem of population is, at the moment, a matter for suspension of judgment and inquiry. Two inquiries in particular are suggested: one, into the potential agricultural resources of the world, analogous to the inquiries made at various times as to coal; the other, into the physical, psychological, and social effects of the restriction of fertility which has become general among European races in the past fifty years.

Transport and its Debt to Science.

Sir Henry Fowler's address to Section G (Engineering) deals with the subject of transport and its indebtedness to science. Since its foundation the city of Liverpool has been associated with transport, and no town owes so much to the facilities to trade which transport has afforded, or has played so frequently the part of a pioneer in the inception of new methods. The Mersey and Trent Canal, the Manchester Ship Canal, the Rainhill Railway trials, the electrification of the Liverpool and Southport railway, and the Commercial Motor Trials of the Liverpool Self-Propelled Traffic Association testify to this.

All advances in methods of transport have been the result of the availability of scientific knowledge. Since the time of Watt these advances have taken place when the "ordered knowledge of natural phenomena" has allowed. Progress has depended upon this knowledge; locomotive design benefited by the experiments of Schmidt; electric traction by the numberless researches into electrical phenomena, and the development of the turbine by Parsons: the work of the latter gave a fresh impulse to marine transport. The motor car and the aeroplane owe much to the Otto cycle and the work of Daimler on internal combustion engines. The above are the results of work on methods of propulsion. The advance in our knowledge of material has also played its part. Until the invention of Bessemer the material requisite was not available in quantities sufficient to allow of much progress being made. The early work of Hadfield on alloy steels has developed in such a manner that the motor car and the aeroplane are possible as we have them to-day. It is not alone in general and large questions that scientific knowledge has helped transport, but it can be shown that a careful investigation of the properties of the steel from which locomotive crank axles are made has led to a large increase in their life.

One great trouble with scientific development on industrial lines is the difficulty of obtaining correct results from practical application. The transport bodies have no axe to grind in the use of any particular thing, and should show their appreciation of their indebtedness to science by freely giving the results of their work.

Another trouble which still exists is that the personal contact of the scientific man and the practical engineer does not occur frequently enough, and the meetings of the Association should be more freely used for this purpose.

Egypt as a Field for Anthropological Research.

As the habits, modes of life, and occupations of all communities are immediately dependent upon the features and products of the land in which they dwell, any inquiry into Egyptian origins ought to begin with the question, What were the physical conditions which prevailed in Egypt and its bordering deserts in the period immediately preceding, and during the rise of, the Egyptian civilisation? Discussing what is actually known about the fauna and flora of the dynastic and predynastic periods, Prof. Newberry, in his presidential address to be delivered to Section H (Anthropology) on September 17, shows that a material change must have taken place in the character of the climate of North-Eastern Africa since pre-agricultural days. The fauna and flora have receded southwards, and the physical conditions which now prevail in the region north of the Atbara are similar to those which prevailed in the deserts on either side of the Lower Nile Valley in early times. The people living in this part of the Anglo-Egyptian Sudan are Hamite, and, as Prof. Seligman has shown, the least modified of these people are physically identical with the predynastic Egyptians of Upper Egypt. Prof. Newberry suggests that they, like the fauna and flora, have receded southwards under the pressure of the advance of civilisation, and that the physical conditions of the country have preserved them to a great extent in their primitive life and pursuits. The picture of life in the Taka country as drawn by Burckhardt in 1813 would, except in some unimportant details, equally well depict the predynastic Egyptians.

Prof. Newberry proceeds to show that the earliest civilisation in Egypt arose in the Delta, and that it spread up the river. Before Menes conquered the north there had been a kingdom of Middle and Upper Egypt, and before that a kingdom with its capital at Sais in the North-Western Delta. The people of the North-Western Delta were closely connected with the early Cretans, and were of the same race as the pre-dynastic people of Upper Egypt. In the Eastern Delta at an early period lived a pastoral clan that had come in from Western Asia and brought into Egypt the domesticated goat and sheep, as well as two important cults connected with trees that were not indigenous to the soil of Egypt. The absence of timber trees makes it doubtful whether the art of the carpenter arose in the Nile Valley. Architectural styles founded on wood construction cannot well have originated in a timberless country, nor could the art of building sailing or sea-going ships. It may be doubted that the custom of burying the dead in wooden coffins arose in Egypt; the resins used in embalming were not native to the Nile Valley. No incense trees or shrubs are known in Egypt, hence it is probable that the ceremonial use of incense did not arise there. Such are some of the anthropological questions raised by a study of the flora of the Lower Nile Valley.

Symbiosis in Animals and Plants.

Prof. George H. F. Nuttall's address to Section I (Physiology) dealt with (1) Symbiosis in plants: lichens; root-nodules of leguminous plants; the significance of micorhiza in various plants, especially orchids; and (2) Symbiosis in animals: Algæ as symbionts in various animals; symbiosis in insects; micro-organisms in relation to luminescence in animals. The subject is one of broad biological interest, an interest that should appeal equally to the physiologist, pathologist, and parasitologist. It is a subject on which much work has been done of recent years, and information relating thereto lies scattered in the scientific literature of different countries.

The term symbiosis denotes a condition of conjoint life existing between different organisms that are benefited to a varying degree by the partnership. The condition of life defined as symbiosis may be regarded as balancing between two extremes, complete immunity and deadly infective disease. Symbiosis has doubtless originated from parasitism. One condition merges into the other, there being no line of demarcation to separate them. Some organisms supposed to be symbionts to-day may prove to be parasites on further investigation. Certain structures that have been described in the past as normal intracellular bodies in animals and plants have in a number of cases been shown to be micro-organisms which can be cultivated or symbionts that are transmissible hereditarily from host to host. The address constitutes a summary of what is known to-day of symbiosis in the animal and vegetable kingdoms. Apart from its scientific interest, the economic importance of studies on symbiosis is exemplified by what has been established, on the botanical side, with regard to the root-nodules of leguminous plants, the germination of orchids, and the origin of tubers.

Mental Differences between Individuals.

The address by Dr. Cyril Burt, president of Section J (Psychology), deals with the mental differences between individuals, with special reference to applied psychology in education and industry. The most remarkable advances made by psychology during recent years consist in the rapid development of what threatens to become a new and separate branch of science; namely, the study of individual differences in mind. The numerous data collected from various fields of applied psychology—from the psychology of education, industry, and war, of mental disorder, deficiency, and crime—are now sufficiently extensive and trustworthy to deserve co-ordination into a single systematic body of knowledge.

Early pseudo-scientific attempts to diagnose mental characteristics from physical and other signs were misled by an inadequate technique. The true procedure was supplied by Sir Francis Galton, who applied to the general problem two special methods of inquiry—the statistical method of correlation, and the experimental method of psychological tests. These in turn rest upon a fundamental assumption, which recent work has verified—the continuity of mental variation. This is the keystone of individual psychology as a science. The differences between one man and another are always a matter of "more or less," seldom, if ever, a question of presence or absence or of "all or none." There are no such things as mental types; there are only mental tendencies.

The general scheme under which individuals are to be studied is much the same, whether they are normal or supernormal, backward, defective, or delinquent, or ordinary applicants for vocational guidance.

The positive foundations for a practical psychology of individual differences have been laid in three broad generalisations, each the separate suggestion of recent experimental work. These consist in a trio of important distinctions: the distinction between intellectual and emotional characteristics, between inborn and acquired mental tendencies, and between general and special capacities. The future progress of individual psychology will consist chiefly in devising more exact methods for examining mental qualities under each of these respective heads.

Aspects of the Study of Botany.

Mr. A. G. Tansley's presidential address to Section K (Botany) deals with some aspects of the development of pure botany during the last thirty or forty years, especially in the British Isles. By means of quotations from representative botanists of the last decade of last century, the views held at that time on the relation of morphology and physiology—that they were two independent "disciplines" or branches of botany—are illustrated. It is pointed out that little progress has been made towards realising the idea of determining the "genealogical tree" of the plant kingdom, and this not so much from the fact that our knowledge is still incomplete, as because, in the recent words of a great authority, it has become evident that the past development of the plant kingdom is represented by "a series of separate lines, some stretching into a remote past, others of more recent origin," and "it would almost seem that 'missing links' have never existed." The increasing doubt as to whether many organs formerly regarded as homologous are really homologous in the strict sense is mentioned, and it is suggested that our increasing, though still rudimentary, knowledge of the factors that determine organic form will lead us to expect a recurrence of the same formative factors, producing similar structures, on different lines of descent, independently of particular life conditions.

The so-called "Neo-Darwinian" account of evolution is then stated, and its weak points indicated; and a description of the changes brought about by the work of Mendel and his followers, of De Vries and of Johannsen, leads to an attempt to form a picture of the origin of species in the light of present knowledge. It is shown that the problems of phylogenesis and ontogenesis are necessarily interlinked, and it is suggested that in the causal study of development of the individual lies the best hope of determining eventually the real nature of the "genes" which geneticists must postulate to account for the observed phenomena of inheritance.

Emphasis is laid on the view that the central and vital part of biology is, and must be, the study of process, and it is suggested that only by stressing this point of view, especially in elementary teaching, will it be possible to retain the power of looking at the science of plants as a whole and thus of checking the disruptive tendencies which have led to the segregation of different branches of the subject.

The Education of the People.

Prof. T. P. Nunn, in his address to Section L (Educational Science), pointed out that the aim of popular education is to train the young to conserve and develop those elements in the tradition of national life and activity which are consciously judged or instinctively felt to be of most worth. Its content will, therefore, always express the distinctive *ethos* of a nation, and, in particular, will reflect the prevalent view as to the proper relation between the individual and the social body. Assuming that in Great Britain we are committed to the ideal of equal citizenship for all, the ultimate aim of our schools must be to bring all children effectively under the influence of those currents in our cultural tradition which have the greatest and most enduring value. Consideration shows that these must include, in addition to our typical traditions of character and manners, the traditions of creative activity represented in literature, science, and the fundamental arts and crafts. The aim thus indicated cannot be achieved so long as education ends for most boys and girls at fourteen; but it does not necessarily imply a "grammar school curriculum" for all. A technical training, provided that it embodies some dignified tradition of intellectual, aesthetic, or practical activity, satisfies the criterion laid down. It is, however, essential that all education should be liberal in outlook and scope.

Science and the Agricultural Crisis.

The main purpose of the presidential address delivered by Dr. Charles Crowther to Section M (Agriculture) is to indicate some of the directions in which immediate help towards the alleviation of the agricultural crisis can be given by the man of science, and some of the lines along which development of our scientific and educational organisation is more especially necessary at this juncture.

The most fundamental of all kinds of assistance that science can give the farmer is that furnished by way of research, but this must of necessity be slow in development, and dependent for the dissemination of its results throughout the industry upon an extensive and efficient advisory organisation in close touch with the farmer.

Similarly also any raising of the standard of farming through formal education can only be effected gradually, and the conclusion is reached, therefore, that the most hopeful way of rendering assistance quickly is through advisory work. The root difficulty of agricultural educational work in the past has been to secure a sufficiently intimate and widespread contact with the farmer, and for this purpose no agency at our command is so valuable as advisory work, involving as it does a contact with the individual farmer which is both direct and sympathetic, originating indeed in most cases out of a direct request for help.

Rapid progress through advisory work postulates, however, a far more numerous staff of advisers than are available at present, some counties being indeed totally unprovided for, while in many others the advisory staff consists of only one man in the person of the County Agricultural Organiser. It is here where the next extension of facilities should take place. In relation to the organisation operating in direct contact with the farmer, research and organised education are for the time being adequately developed—the latter indeed producing now a considerable surplus of trained men for whom employment in educational work is not available. This in itself implies a certain loss of proportion in the development of the whole agricultural educational organisation, and is to be remedied by the extension of the base upon which the whole structure rests, which is constituted of advice, elementary agricultural education, and propaganda. At the same time a closer degree of co-ordination and co-operation between the various elements of the educational organisation is desirable.

In conclusion, although advisory work may be our most effective means of rendering immediate help, a more permanent contribution to the future prosperity of British agriculture will be made through our educational system in the training of the farmers of the future. As yet we have not succeeded in persuading the general body of farmers that technical education is an essential element in the training of the young farmer. The natural development of such a conviction must perhaps be slow, but might be greatly accelerated if more importance were attached to scientific training as well as practical experience in the letting of farms.

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