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Atomic Structure and the Quantum Theory.

WE publish this week, as a special supplement, the substance of an address by Prof. N. Bohr on the development of the theory of atomic structure, and in particular of the latest form and tendencies of the quantum theory in their relation to mechanics. New points are raised which seem likely to be of such importance that some attempt at a general description may be of interest. The prevailing theory of atomic structure, which we owe so largely to Prof. Bohr himself, might be characterised as "the central orbit theory." In this theory we visualise the atom as a nucleus surrounded by electrons. Each of these moves in a mechanical (but non-radiating) nearly central orbit, characterised by special fixed values of energy and angular momentum which are functions of two quantum numbers. The immense success of this theory in co-ordinating the facts of optical and X-ray spectroscopy and the general physical and chemical periodic properties of the elements is well known, and its correctness in broad outline is scarcely open to question. But it is equally certain that in its finer details the theory has proved inadequate. As soon, for example, as we begin to ask why the D-lines of sodium are a doublet instead of a single line, we leave the certain field of the theory for far less certain extensions. We can introduce formally the third quantum number necessary to "explain" the doubling (trebling, etc.) of spectral lines, and similarly the fourth quantum number necessary to "explain" their splitting in a magnetic field. Such "explanations" are elegant in form and convincing so far as they go, but when we try to interpret them on the basis of natural extensions of the mechanical model of the central orbit theory, we meet at every turn with perplexing contradictions which suggest that the proposed revision of the theory has up till now scarcely been sufficiently fundamental.

On another point the prevailing theory has proved somewhat inadequate. It has put forward a semi-mechanical model of the atom, which possesses mechanical frequencies. It is well known, however, that these differ from the observable frequencies of the atom, as shown, in the only way they can be shown, by their action on and reaction to radiation. There is only an asymptotic equality between the two sets of frequencies for large quantum numbers. The theory has, however, been able to derive the exact observable frequencies from the mechanical frequencies by a *transformation* (Bohr's frequency condition) which forms an essential part of the postulates of the theory. The asymptotic equality, however, between the properties of the mechanical model and of the atom of any quantum

theory seems certain to subsist, not merely for frequencies but, generally, for all properties, including amplitudes or intensities of the various component oscillations. Underlying this there is doubtless an exact intensity relationship to be brought to light by a suitable transformation of the mechanical one, as Bohr's transformation brought to light the exact relationship for frequencies. Special cases of this relationship have already been recognised and embodied in what have been called " refined " applications of the correspondence principle. Some are old, such as the selection and polarisation rules: others more recent and perhaps more artificial, such as the summation rule, and the general intensity rules for multiplets and for the components of a line split by a magnetic field. But these are only special cases, and one can scarcely rest content with any transformation which utilises less than all the information about intensities as well as frequencies which the model can provide.

These and other similar ideas underlie the new attempt to formulate a more satisfactory theory, recently made by Heisenberg. Heisenberg's " transformation " of the equations of mechanics is much more general than Bohr's. Every mechanical quantity appearing is transformed at once in the new theory into an observable quantum quantity, so that the new theory does employ *all* the available information and provides complete intensity rules as well as frequencies for any soluble model. The mathematics required will be severe—in particular, the necessary algebra must obey a non-commutative law of multiplication and progress may be slow. In fact, once again physical theory seems likely to be a source of inspiration to mathematical thought. But enough appears to have been done to make it most probable that the new quantum theory will be still more fertile than the old, and to justify a hope that it may resolve some at least of the difficulties which now confront extensions of the older theory. Students of the quantum theory will wait with impatience for the publication of the results hinted at in Prof. Bohr's concluding paragraphs.

Weeds and their Control.

Ugress i nutidens jordbruk (*Weeds in present-day agriculture*). By Emil Korsmo. Pp. 694. (Oslo, Norway: J. W. Cappelens, 1925.)

THE eradication of weeds is regarded by many people as merely a matter of practical farming to which scientific methods have no application. This, however, is far from being the case, and it would be equally logical to deny the importance of science in other branches of agriculture. The possibility of effective control will increase in proportion to the increase in our knowledge of the plants usually regarded as weeds, especially with regard to their habits and conditions of growth, revealing vulnerable points at which they may effectively be attacked.

The close study of weeds, with the direct objective of methods of control, brings to light valuable and interesting biological characters and relations of many widespread and common plants. Biological investigation from this point of view is a comparatively recent development, and no comprehensive work on the subject has hitherto been published, rendering this volume by E. Korsmo (professor in weed science at the Norwegian Agricultural College at Aas) a most welcome addition to botanical and agricultural literature. The book comprises the results of laborious and careful researches, representing much pioneer work, and extending over a period of thirty years. The author, however, is fully justified for the labour expended, as it must be admitted that the volume is probably the most valuable, from the biological point of view, of those hitherto published on the subject. The extensive collection of facts and their careful treatment are quite convincing, and reveal a power of observation combined with a patience in research which must awaken admiration. To sum up, the work is as conclusive as it is comprehensive and interesting.

At the outset, weeds are classified into biological groups determined by the author from the practical point of view, as follows:

(1) Weeds multiplied by seeds only, including annual, " winter annual," and biennial plants.

(2) Perennial weeds which multiply by seeds but may form clusters of shoots if the root is injured.

(3) Perennial weeds which multiply mainly by creeping shoots.

Under each of these headings are various subdivisions which differentiate Korsmo's classification from those usually employed, and are based essentially upon differences of habit. Every species dealt with is minutely described throughout its life-history from seed to seed, and the numerous careful and detailed drawings make the book of great value to botanists as well as to agriculturists. Indeed two-thirds of the book is devoted to the botanical aspect of the subject. The scope of the work may be indicated by a reference to *Chenopodium album*. Its appearance, distribution, times of flowering and ripening of seed are given, together with large-scale drawings. The power of germination of the seed after burial at different depths has been determined by direct experiment, and the occurrence of the seeds in such substances as chaff, hay refuse, seed mixtures, dung, etc., is outlined. The description concludes by analyses of the mineral constituents of the plant, showing to some extent its demands upon the soil, and analyses of the organic constituents, which may indicate its feeding value for animals. Most of the work is original throughout, but

various figures and statements are quoted from other authors to strengthen the arguments or to point out the different results sometimes obtained under other conditions.

On the practical side is set forth the damage wrought by weeds, their differing capacities for spreading themselves and the best means of eradication and control. The value of systematic weed eradication is emphasised by numerous figures from experimental trials showing considerable increases of crop where good methods have been adopted. These chapters are of special interest to the practical farmer, and if the advice given were carefully followed out it should result in considerable decrease in the weed population, and a corresponding increase in the space available in the fields for actual crop growth. For many years Korsmo has been adopted by the government as weed adviser to the farmers, and has in that capacity gained a wide practical experience. His fundamental idea is to show the possibility of an economic fight against weeds, provided it be acknowledged that the old time-honoured methods are not sufficient, and that newer and more scientific methods must be brought into play, and he has endeavoured to point out that under these conditions excellent results have been obtained.

The book is written in Norwegian, making it comparatively inaccessible to the ordinary student, and an English translation is much to be desired to bring it within reach of the many whom it will deeply interest.

A. Å.

W. E. B.

Medieval Anatomy.

Monumenta Medica. Under the General Editorship of Henry E. Sigerist. Vol. 2: *The Fasciculo di Medicina, Venice, 1493.* With an Introduction, etc., by Charles Singer. Part 1: *Description of the Fasciculo; Discussion of its Editions, Art, Language, Sources, and Influence; Translation of the "Anathomia" of Mondino da Luzzi; An Account of Medieval Anatomy and Physiology; and an Atlas of Illustrative Figures from Manuscript and Printed Sources.* Pp. 112+73 (Atlas). Part 2: *Facsimile.* Pp. 108. (Florence: R. Lier and Co.; London: D. Stanton, 90 North Road, Highgate, 1925.) Half-linen, 66*s.*; half-leather, 80*s.*

THESE two stately volumes, which form an abiding memorial of Dr. Singer's scholarship and research, will appeal alike to the medical historian, the antiquarian, and the artist.

The "Fasciculo di Medicina" is a collection of medical treatises which was first printed in Latin at Venice in 1491, when it had attached to it the name of Johannes de Keetham, which according to Prof. Sudhoff is a corruption of Kircheim. It is remarkable as being not only the first illustrated medical book, but also as being the best-illustrated work that had hitherto appeared.

The second edition, which was published in 1493 and is here reproduced in facsimile, differs from the first by containing among other additions the "Anathomia" of Mundinus or Mondino da Luzzi.

The "Fasciculo" passed through many editions, of which thirteen are known to Dr. Singer. The last appeared at Venice in 1522. A belated edition is said to have been published in the seventeenth century, but Dr. Singer has been unable to verify its existence.

Of the two volumes before us, the first contains a commentary on the "Fasciculo," including a discussion of its editions, art, language, sources, and influence, as well as a complete translation of Mondino's work. An atlas of illustrative figures from manuscripts and printed sources with explanatory legends is appended.

The second volume consists of a facsimile of the second edition of the "Fasciculo," and contains, in addition to the text, ten full-page illustrations including one in colour.

The illustrations comprise, among others, figures of the vein man, the wound man, and the zodiacal man, but those most worthy of attention are the frontispiece representing Petrus de Montagnana, the professor of Padua, seated at his desk surrounded by his books, with his waiting-room containing three patients in the foreground; a figure of a puerperal woman remarkable for being the earliest instance in a printed book in which an organ of the body, in this case the uterus, is drawn from the object; and a dissection scene which forms one of the earliest examples of printing in colours.

The "Anathomia" of Mundinus, who has been called the "Father of Modern Anatomy," represents the principal item in the "Fasciculo." In spite of its elementary character and numerous inaccuracies, such as the descriptions of a spherical stomach, a five-lobed liver, and a spleen with imaginary channels evacuating the black bile into the stomach, the work forms a landmark in the history of anatomy, though, as Dr. Singer points out, it is less a text-book of anatomy than a post-mortem manual. Its errors were doubtless partly due to the fact that, owing to the absence of preservatives, anatomical examination had to be performed very hurriedly. The whole procedure did not occupy more than four sessions, the first being devoted to the abdominal viscera, the second to the thoracic organs, the third to the head, and the fourth to the extremities. Subsequent reforms in anatomy were due to artists such as Mantegna, Pollajuolo, Michelangelo, and especially Leonardo da Vinci, rather than to professional anatomists.

Dr. Singer is entitled to special commendation for his translation of the "Anathomia," which, in view of the nomenclature, corruptness of the text, complexity of style, and confusion of thought and expression, was an unusually difficult task. An archaic style has been adopted in the translation, and most of the anatomical and technical nomenclature of the original has been preserved, the terms being explained in a glossary.

The Methods of Systematic Zoology.

Reform der paläozoologischen Nomenklatur. By Rud. Richter. Koehler's *Nachrichtenbl. f. Geol.* 2, Nr. 1-2. (Leipzig, 1925.)

Handbuch der biologischen Arbeitsmethoden. Herausgegeben von Prof. Dr. Emil Abderhalden. Lieferung 144. Abt. 11: *Methoden zur Erforschung der Leistung des tierischen Organismus.* Teil 1, Hälfte 1, Heft 4 (Schlussheft): *Allgemeine Methoden. Allgemeine Methoden des zoologisch-systematischen Arbeitens: die Nomenklatur.* Von W. A. Collier. Pp. 585-676+xii. (Berlin und Wien: Urban und Schwarzenberg, 1924.) 4·20 gold marks.

THESE two publications are welcome as a sign that some attention is being paid to the rules and methods of systematic zoology in quarters where there was much need of more observance. Most of those who are professional systematists have learned from sad experience the harm that has been wrought by want of thought in these technical details; none the less, many zoologists, often eminent in their own lines, continue to commit the same faults as their predecessors and to sow fresh seeds of future confusion. If authors cannot be made to realise their responsibility, there should at least, as Dr. Richter urges, be some hope of impressing editors and publishing bodies with a sense of their still greater responsibility. A committee of the British Association has for many years tried to do this, with some success no doubt, but evidently not with enough. The fact is that in Great Britain at least, and apparently in most other countries, systematic biology is no longer a "discipline." Our universities provide no training in either its principles or its methods; with rare exceptions the professors are as ignorant as the students. The botanists still retain a tradition of Linnæus, ornithologists and entomologists are forced in self-defence to have some method, but the young man who wishes to describe new species in any other groups is fortunate indeed if he has a competent elder colleague to guide him.

If these wanderers recognised their need they would welcome a brief work covering the field implied in Dr. Collier's title. In his text as it stands they will find some good counsel and some sound directions, but he is not in all respects a safe guide. He is to be commended when he advises a knowledge of the living animal, when he protests against the dispersal of related material through a multitude of minor museums, or when he condemns those who base new species on the descriptions or figures of other authors without themselves seeing actual specimens. Excellent too is his advocacy of precise measurement and numbers, of a recognised colour-scale, of reasonable citation of references as opposed to a peppering of *loc. cit.* and *ibid.*

Sometimes, however, Dr. Collier is not so satisfactory, and occasionally he is actually misleading. The rules of the International Zoological Congress for the placing of figures are good, but need supplementing for the Invertebrata. There is, for example, a recognised way of orienting figures of various echinoderms. A warning is needed against filling a plate with figures lit from different points of the compass—a piece of carelessness that is as irritating as it is inartistic. Reference-letters affixed to drawings are better than nothing; but there is usually plenty of room for the whole word, and its use saves much time. Though many zoologists lessen the value of their work by giving some vague or inaccurate name to their material (*e.g.* "the common sea-urchin"), it scarcely seems necessary to rule that a complete and personally verified synonymy should be prefixed to every systematic note. It is frequently enough to refer to some clear and accessible description and figure. Still, even pedantry is preferable to a lack of precision, for experience shows that a name unsupported by evidence is of little value. Dr. Collier is entitled to use the expression "Trivialnamen" for vernacular names, but it seems a pity to do so, seeing that in the Linnæan system of nomenclature the *nomen triviale* is the second component of the *nomen specificum*, the first being the *nomen genericum*. The few remarks on type-specimens are not free from error. The erroneous definition of "paratype" is particularly unfortunate; that of metatype is incomplete; "homotype," which was preoccupied, has long been replaced by "homoeotype," but it is little needed. Nothing is said about the subsequent selection of holotypes and genotypes, although this is one of the most important and most difficult questions for a systematist.

Apart from these details, important as they are in a handbook of practice, the whole of Dr. Collier's work seems to be weakened by what may be called a topsy-turvy philosophy. Quite correctly he divides systematic work into analysis and synthesis, the analysis consisting in the discrimination of units and their precise description in every aspect, the synthesis which follows being the building up of these units into the hierarchy of systematic categories. As a method of research this

has very much to commend it, and the author could have made a still better case for it had he paid any attention to phylogenetic inquiry, especially that undertaken by palæontologists. But this synthetic method cannot be applied to the practical work of description and exposition; here a fresh analysis is needed. Nevertheless, directions are given for the construction of a system from below upwards, and there are many expressions which seem to imply that the definition of each category should summarise the characters of all its constituent inferior categories.

This method consistently carried out would break down of its own weight. Surely the method most natural to the human intellect is the old logical series of definitions *per genus et differentiam*. Here one begins at the top and gradually works downwards by repeated subdivision. There is no good reason as yet for discarding so clear and concise a method. Nowadays we find some authors establishing new genera or species without any diagnosis at all, and other authors introducing into a wordy description abundance of matter as unnecessary as the statement that a new species of Equus has four legs and a head. Had Dr. Collier explained the construction of an old-fashioned diagnosis he would have done a useful service and might have spared a good deal of less practical discussion. His work as it stands is disappointing. F. A. BATHER.

A Register of Harrow School.

The Harrow School Register, 1845–1925. Second Series. In 2 vols. Edited by J. H. Stogdon. Vol. 1: 1845–1885. Pp. xi+472+113. Vol. 2: 1885–1925. Pp. xi+442+113. (London: Longmans, Green and Co., 1925.) 15*s*. net each vol.

TWO big volumes full of names, a fireside, and an editor who requests a notice of the book: where shall we begin? A list of distinguished Harrovians might be attempted, but NATURE would never print it and we should annoy some we forgot to mention. The worst of books like these is that it is impossible to do anything straightforward with them. One is always being sidetracked by something which catches the eye as one turns the pages. What about the editor of the book himself, what sort of fellow is he? Doubtless a clerkly man, but he must have a great love for his school to undertake the colossal task of this compilation. There is his name on the title page, "*J. H. Stogdon*, Member of the Stock Exchange." Now for the index: there he is again, 1889/3. Back to that term in the book: there is his name under that of his headmaster, *Bishop Welldon*—just a seven-line entry, which reveals that at school he was captain of cricket and winner of public schools rackets; that he got his "blue" at Cambridge for both these games; and that he served with the R.N.V.R. in the War—a man we should like to know.

This is the way one reads a register, but it is scarcely a "review." Let us try what Church and State can offer. Five Harrovians, including the Prime Minister, are in the present Cabinet. There were two in the last one, which says something for the breadth of view taken from the Hill. The *Archbishop of Canterbury* is an Harrovian and a governor of the school. The latest and youngest addition to the Episcopal bench, *Dr. E. A. Burroughs*, is another Harrovian. Generals *Smith-Dorrien*, *Lawrence*, and *Lord Horne of Stirkoke*, also a governor of the school, represent Harrow in the army, as does *Sir Gerald du Maurier* on the stage. *Dr. Walter Leaf*, combining classical scholarship with finance, is equally renowned in each. *Col. the Hon. F. S. Jackson, M.P.*, is even better known for his cricket than for the minor interests indicated in his style, though he raised and commanded a battalion in the War and is chairman of the Conservative and Unionist Central Association. "A Gentleman's A-bowling" is a song which every Harrow boy knows and sings.

Of the nine fellows of the Royal Society whose names appear in the Register, *Lord Rayleigh* is the most famous Old Harrovian. *Sir H. K. Anderson, F.R.S.*, who now represents science on the governing body, is master of Caius College, Cambridge. At Oxford, *Dr. F. W. Pember*, Warden of All Souls, stands for Harrow and classical learning. This reminds one that *Dr. Godley*, the recently lamented Public Orator at Oxford, came from Harrow. So too did *Calverley*, but Godley had all his wit and more stability: at least he did not "migrate," as the Register so kindly puts it, from Balliol to Christ's.

Let us look up Godley. There is his name: came in 1869/1, while *Henry Montagu Butler*, the late Master of Trinity, was headmaster. What schoolfellows Godley had! The following names occur in the year of his entry: *William Henry Grenfell* (*Lord Desborough*), chancellor of the Primrose League, president of the London Chamber of Commerce, chairman of the Thames Conservancy Board, who in his youth was president of the O.U.B.C. and O.U.A.C., swam Niagara and stroked an eight-oared racing boat across the Channel; *Walter Hume Long* (*Baron Long of Wraxall*), who was in succession Secretary and afterwards President of the Local Government Board, President of the Board of Agriculture, Chief Secretary for Ireland, First Lord of the Admiralty and Secretary of State for the Colonies; *Walter Sydney Sichel*, barrister and author; *A. J. Webbe*, for many years captain of Middlesex Cricket Club; *A. S. Hewlett*, who left missionary work at home to minister to the lepers in Japan; *G. F. Chance*, at one time chairman of Chance Bros. and Co. and high

sheriff of Worcestershire; *P. N. Evans*, whose brilliant career as a consulting chemist was cut short by death in 1893; *H.R.H. The Duke of Genoa*, admiral in the Italian Navy, who was offered the crown of Spain while still at school; and *William Dodge James*, one of the first explorers of Somaliland. A notable year, one may say; but, in fact, it is an average one: at least, it was taken at random.

The Register reveals that, in 1845, the number of boys in the school was about half of the present one, which is about 650. Although *John Lion*, the pious founder, received his Charter from Queen Elizabeth, it was not until the early years of last century that the school outgrew the original buildings. In 1880 the boarders could all be accommodated in the houses of four "dames," whose names are recorded in the Register. *Dame Armstrong's* house has recently been pulled down to clear a site for the war memorial buildings which now approach completion. Nearly all the fame of Harrow has been won since the days of *Sheridan* and *Byron*.

It is worth while to consider the reasons for the success which seems to fall to the lot of Harrow's sons. "Influence," the sceptic may say: well, that counts for much, where the parent knows his world and exercises good judgment. Wealth? No, it is nearly true that the less money a man has, when his education is done, the better off he is. Scholarship? No again, so far as schooling goes. We are nearer the mark when we hazard freedom of thought and the absence of early pressure on immature minds. But the real secret lies in the spirit of service, for the leaders of men will always be chosen from those who have proved themselves willing to give of their best without thought of reward. This is what British public schools stand for, and it is the happiest augury for Britain in these distressful times, that there is growing up a whole host of secondary schools with the same ideals.

Unknown Egypt.

Ministry of Finance, Egypt: Survey of Egypt. Geology of Egypt. Vol. 1: *The Surface Features of Egypt, their Determining Causes and Relation to Geological Structure.* By Dr. W. F. Hume. Large 8vo. Pp. xliv+408+122 plates. (Cairo: Government Publications Office, 1925.) P.T. 50 (10*s.* 3*d.*).

THIS is a study of the conditions of a region which, though easily accessible, is not known to more than a dozen visitors beyond its mere fringe. Of the thousands who go up and down the Nile, not one in a year goes a march into the high desert. The two hundred views here are a joy to any who know the glorious spaciousness and scenery of the wild, and the many questions that arise in trying to visualise its history. Eocene hills capped with crystallised calcite, or mountains with Tertiary basalt tops; the torrential gravels high up, with boulders which pounded the *ostræa* until it grew shells an inch thick; the collapsed strata dropped four hundred feet into caverns which fed the deep Nile gorge; all these are alluring prospects. The subjects discussed in this volume are naturally more physical than stratigraphic, as dealing with the surface conditions, and in several directions further experiment is needed to solve questions. After an outline of the past work by various nationalities, the variations of temperature are stated as leading to scaling of the rock, often under a difference of 50° C. The effect of this in flaking away architraves when ancient roofing is lost, might well be added.

An important chapter is that on the formation of sand dunes, and on sand erosion. The various types of dune are described, the size up to 30 metres high, the advance of 10 to 20 metres yearly, and the means of arrest. There does not seem to be a known cause for the difference between the ridge dunes, up to 50 or 100 miles long, and the rounded crescent dunes. No doubt one is favoured by a uniform direction of wind, the other by shifting winds which scour round the convexity, but it is not clear how such types begin. A beautiful example of seven parallel ridges, about a quarter of a mile apart, with grassy plains between, might be quoted from the south of Behnesa. The formation of oases is attributed to wind scour, but it is hard to imagine wind scooping out more than 500 feet depth of rock with steep sides, as in the Fayum; it looks more as if seepage had dissolved away lower strata of Eocene limestone into the adjacent Nile gorge, when that was empty to many hundred feet below the present level.

The action of rain is considerable, for though it is rare, the sudden amounts are violent, in the absence of vegetation. The formation of limestone caves is noted; the cisterns natural and artificial are described, some holding up to 500 tons. Forms of denudation on different kinds of rock are finely illustrated. The underground water is largely in the porous Nubian sandstone, which supplies the oases, and can be tapped by wells 250 feet deep in the intervening desert. Deep water supplies, independent of the Nile, are found at 150 to 300 feet, and now supply the larger cities. Frequent discussion has arisen about the black films formed on rocks and stones. These are stated at some length, referring to the sandstone rocks, loose flints, large siliceous nodules, and the granite rocks washed by the Nile. The colour is due to iron and manganese; these are supposed to be dissolved by the dew and brought to the surface by evaporation; but a difficulty is that such colouring is seen on flints which have no

depth to supply the colour. A ground-water source is also stated, and thought probable. The strong tendency of manganese elsewhere to form dendritic crusts, should be considered in this connexion. Another mode of surface action, which is not noticed, is the hardening of limestone superficially, while it crumbles away inside, thus forming a hollow box. Similar internal crumbling—or possibly sea action—is seen in the sentry-box caves formed in the red granite of Sinai. The natron lakes, soda supplies, and soil analyses are also fully dealt with.

There are several other subjects noticed in the 219 pages, and it is clear that there are many matters which need more study, as on scarcely any point is there finally conclusive information. In spite of a bibliography of 912 works, Egypt is still an open field for investigation in many lines, and Dr. Hume obviously would welcome scientific work auxiliary to his department. The facilities of this volume are admirable; the bibliography of 68 pages has a subject index of 10 pages; and the whole 314 pages have a remarkably full index of 94 pages. A geological map on 1 : 2,000,000 is supplied at the end, and there are half-a-dozen detail maps beside the wealth of photographs. The work bears imprints of 1922, but was delayed in issue until 1925. We hope that we may soon see the next volume, and that the Nile borders may be described as well as the desert.

FLINDERS PETRIE.

Our Bookshelf.

(1) *The Fundamentals of Statistics.* By Prof. L. L. Thurstone. (Experimental Education Series.) Pp. xvi+237. (New York: The Macmillan Company, 1925.) 8*s.* 6*d.* net.

(2) *Statistical Methods for Research Workers.* By R. A. Fisher. (Biological Monographs and Manuals.) Pp. x+239. (Edinburgh and London: Oliver and Boyd, 1925.) 15*s.* net.

MODERN statistical methods are now used in such widely different spheres of activity that it is natural that several books on the subject should be produced to meet the needs of the various persons concerned. It is of interest to notice that these books, being of the text-book variety, usually assume an air of certainty with regard to some things which are still almost within the region of controversy. This becomes the more obvious as the subject-matter becomes more advanced.

(1) Turning to the two books before us, we find that Prof. Thurstone has set himself the task of providing an elementary book on statistics for students of psychology who have little mathematical knowledge. The book is about as elementary as it can be, and it assumes that the reader is so poorly equipped as to need to have the graphical expression of a straight line and the most elementary aspect of the binomial series explained. It will, however, enable these non-mathematical students to follow, in a reasonable way, results obtained by others and expressed in terms that would be meaningless without some help such as this book gives. A good many elementary books of this kind have been published in recent years in the United States, and this is one of the best of them.

(2) Mr. Fisher's book is written for a more advanced type of reader, and it has much to commend it. It treats of the interesting and important subject of small samples in statistical work; it has originality; its author is full of ideas, and its appearance is all that can be desired. But, unfortunately, the book suffers from an introductory chapter which seems unnecessarily hard to follow, and from the difficulty of the subject, which has, we fear, often prevented Mr. Fisher from writing down to his reader. The book is intended for biological research workers, and it is apparently assumed either that they already know sufficient of the theory to accept, without proof, the methods given, or that they will adopt those methods on Mr. Fisher's authority. A statistical "research worker" may be willing to dispense with rigid mathematical proofs when it can be seen from several arithmetical examples that a method carries its own justification, but in the present work the absence of proof goes rather far, and we fear that readers with little knowledge of the most recent statistical work will find the book as a whole difficult to follow, while those unfamiliar with the terms used in biological research work will have trouble with some of the examples.

In many places throughout the book a reader may hesitate, wish perhaps that he could share Mr. Fisher's confident assurance, and then find himself wondering whether deep down under much of the theory about which Mr. Fisher is so sure, there may not lurk the assumption that we can approximate to the whole population from a sample in a way that resembles the theory of "inverse probability" which he "wholly rejects."

It seems to us probable that the book will be read as much by statisticians who wish to study Mr. Fisher's methods and views as by those research workers who merely went to apply the methods he describes. Such readers will find so much that is interesting, suggestive, and useful that they will forgive the weaknesses we have tried to indicate.

The Theory of Electric Cables and Networks. By Dr. Alexander Russell. Third edition. Pp. xii+356. (London: Constable and Co., Ltd., 1925.) 24*s.* net.

WITH the rapid growth of electrical distribution, and the increasing size of networks, the most economical design of the distributing system is becoming more important every year. The third edition of Dr. Russell's well-known book will therefore be welcomed by all engineers who are concerned with cable manufacture or with the business of electric distribution. This edition does not differ very much from the second edition, which was published in 1919, nor is it necessary that it should, for the book deals mainly with fundamental principles.

The tables of standard sizes of wires and cables and of the electrical and thermal constants of materials are of great value, and the discussion in the second chapter of the mechanical and electrical properties of copper is one of the most complete that is to be found in any standard text-book. Equally thorough is the study of insulativity and insulating materials. The treatment

of distributing networks and the determination of the fault resistance of such networks is especially good. The author has himself contributed largely to the technical literature of this subject, and his method of finding fault resistance is well known to all distribution engineers.

Dr. Russell is also a well-known authority on dielectric strength. This subject is of growing interest on account of the higher pressures at which cables are being operated. The heating of cables is discussed, but in any future editions of the book it is hoped that reference will be made to the heating of buried cables and to the extensive researches that have been carried out in recent years under the auspices of the Electrical Research Committee. The chapter on electrical safety valves, also, should include some reference to the lead peroxide arrester, which is now being used so largely in the United States.

The chapter on lightning conductors contains material which is not available except in the *Proceedings* of learned societies, and the new appendix on the interesting problem of the most economical site for a power station is of special value in view of the growing importance, economically, of the electrical aspect of this problem. This book is well known as a standard textbook on the theory of electrical cables and networks, and should be on the shelves of all cable manufacturers and distribution engineers.

The Journal of the Institute of Metals. Vol. 33. Edited by G. Shaw Scott. Pp. xii+710+15 plates. (London: Institute of Metals, 1925.) 31*s.* 6*d.* net.

SCIENTIFIC readers of the new volume of this Journal will probably turn first to the May Lecture, in which Prof. H. A. Lorentz deals in a most fascinating manner with the most recent knowledge of the motion of electricity in metals, including the determinations of the velocity of moving electrons in a conductor, and with the phenomena of super-conductivity. The whole lecture is a model of reasoning and exposition. The papers contributed to the Institute cover a wide range, the properties of the various alloys of copper occupying as usual a considerable proportion of the space. Problems of corrosion are dealt with in several papers, and it is satisfactory to notice that the apparently irreconcilable positions taken up by different investigators have now been examined in an impartial spirit, and an agreed statement has been issued, so that further experimental work can proceed without the atmosphere of controversy which has so long enveloped the subject. An important practical paper describes experiments on the production of castings of aluminium alloys with greatly diminished porosity, the method used being to free the alloy from dissolved gases by bubbling nitrogen through the liquid just before solidification, afterwards remelting. The inert nitrogen washes out the gases which give rise to blowholes, and sound castings result. This method has also been applied with success to other alloys. More than half of the volume is occupied by abstracts of work published elsewhere, and this section is invaluable to the metallurgist, the abstracting being done with remarkable thoroughness, so as to include research in pure physics and chemistry wherever it touches metals. The arrangement is clear, and the method of presentation is attractive.

Abbeys. By Dr. M. R. James. With an additional Chapter on Monastic Life and Buildings, by Dr. A. Hamilton Thompson. Pp. x+154+107 plates+13 plans. (London: Great Western Railway, Paddington, 1925.) 5*s.* net.

IT is only fair to warn the unwary that this book is not a treatise on abbeys in general, or a comprehensive survey of the abbeys of Britain. It deals only with those abbeys which are on or accessible from the Great Western Railway system. There is no hint of this on the title-page, except in the publisher's imprint, which many will not notice. It is, in fact, a glorified guide-book; but a guide-book of a type which we wish were more frequent. Nearly every building is illustrated in one or more photographs, excellently reproduced. In addition, several examples of the priceless manuscripts which were produced by the monks of the abbeys are given in colour. The letterpress of the Provost of Eton is to a great extent, though not entirely, a compilation. As he explains in his preface, he has visited most of the buildings, and to his authorities he has added something of his own. Not only are the buildings adequately explained for the needs of the visitors, but the author has also brought out in each case the relative importance of each and of the community to which it belonged. The list of abbeys classified according to religious orders will be found a great convenience. Prof. A. Hamilton Thompson has contributed an admirable chapter on monastic life. The book is a remarkable production at so low a price.

Summation of Series. Collected by L. B. W. Jolley. Pp. xi+232. (London: Chapman and Hall, Ltd., 1925.) 13*s.* 6*d.* net.

A COMPREHENSIVE collection of series and their sums would be invaluable to the university teacher, the research worker, or the technician, according to the principle guiding the selection, but an attempt to cater for all parties must necessarily spell failure. The present volume, containing about seven hundred series, is well arranged and includes individual types easy of reference. The series are set out clearly on one page, and the sum on the page facing. In spite of the compiler's intentions, we believe the collection will be of value mainly to the not too advanced student. Fourier series, Bessel functions, and elliptic functions are treated in cursory fashion, although quite a number of Fourier series are classified under the heading of trigonometric series. The general expression for Fourier coefficients does not appear to be given. It is eminently desirable that the limits of the variable within which the series is a valid representation of its "sum" should be systematically stated—a dangerous omission if the collection is intended for the use of the technician.

Life: a Book for Elementary Students. By Sir Arthur E. Shipley. Second edition. Pp. xvi+204. (Cambridge: At the University Press, 1925.) 6*s.* net.

IT is a pleasure to find that Sir Arthur Shipley's little book, which was reviewed in NATURE of July 5, 1924, p. 6, has been so much in demand that a second edition has already been called for. A few minor changes have been made.

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.*]

Selective Action of Polarised Light upon Starch Grains.

In a recent note (*Annals of Botany*, 39, 651, 1925) Prof. Neilson Jones has criticised our statement (*Proc. Roy. Soc.* 97 B, 250, 1924) that starch grains are selectively hydrolysed by polarised light in the presence of small quantities of diastase. Prof. Jones is under a misapprehension when he says that we accepted the frilling or serration of the grains as evidence of hydrolysis. We did not do so, for what we observed was the complete disappearance of the starch grains when illuminated with polarised light, slight serration only occurring in heterogeneous light. Further, after complete hydrolysis of the starch grains by polarised light, the solution deposited crystals which reduced Fehling's solution.

If Prof. Jones is correct in saying that the serration of the starch grains may be caused by other influences, he removes the last difficulty from our minds, namely, the slight change we observed with heterogeneous light. This may now be attributed to those secondary effects and not to incipient hydrolysis.

As the principal cause of these secondary effects Prof. Jones cites the pressure of the cover slide, but this naturally cannot account for the disappearance of the starch grains and their conversion into crystalline compounds which reduce Fehling's solution.

If any doubt remains on this point, we are now able to say that when starch grains in pure water are placed in a Petrie dish or in a flask and illuminated with a strong beam of polarised light, they are hydrolysed. The breaking down of the grains is obvious when they are examined microscopically, and the aqueous film on evaporation deposits crystals which have been found to reduce Fehling's solution.

Although in our paper we refrained from entering into the theoretical explanation of the phenomenon, it is obvious that it must be connected with a selective absorption of polarised radiant energy by the optically active starch grains. In this connexion, the observations made by Liebisch and Rubens of the different absorptive power for polarised and ordinary infra-red radiation of optically active crystals are of great significance (*Berl. Ber.*, 1919, 198 and 876).

Prof. Jones makes no mention of other observations which confirm our results. These observations may be divided into two classes, namely, those which had been made previously to the publication of our paper and may be explained by our results; and those observations which have been definitely undertaken as the result of our work. Amongst the first group we may quote the work which was carried out by Knauthe on the influence of moonlight on the photosynthetic processes of certain plankton. His results are quoted at length by Kofoid (*Bull. Illinois State Labs. Nat. History*, 8, 305, 1908). Knauthe found that the relative efficiency of moonlight and sunlight was about 2 : 9, and Kofoid considers this ratio to be smaller than the maximum and above the average. The relative intensities of sunlight and moonlight were given by Zollner as 618,000 : 1, and it would seem, therefore, that for equal intensities moonlight is more than 100,000 times as efficient as sunlight. Kofoid followed up this work and established an undoubted correlation between the maxima in the seasonal variation of these micro-organisms and the period of the full moon. This phenomenon may well find an explanation in the fact that moonlight is on the average polarised to the extent of 10 per cent.

As a second example of the well-known influence of polarised light we may mention the peculiarly bad effect on the eyes of the light scattered from a snow field, a phenomenon which is painfully familiar to mountaineers. The high polarisation of such light is well known.

We may also refer to Padoa's observation that crystals of *o*-nitrobenzaldehyde are selectively decomposed by polarised light, provided that the crystals are correctly oriented to the plane of polarisation (*Atti R. Accad. Lincei*, 28, 372, 1919). Other similar phenomena are probably too well known to need mention, such for example as Weigert's observations of the effect of polarised light on the photographic plate.

Of the second group we may quote Morrison's proof of the selective action of polarised light on the growth of luminous bacteria, *e.g. Photobacterium phosphorescens* (*Science*, 61, 392, 1925), an observation which has been confirmed by Macht and Hill of the Johns Hopkins University with *B. coli* and *B. typhosus* (*Proc. Soc. Exp. Biol. and Medicine*, 22, 474, 1925). Mention may also be made of Bryant's observation that the polarised light from the moon has a selective action in causing the putrefaction of pieces of fish (*J. Chem. Ind.*, 42, 681, 1924).

Then, again, we may mention the observation by Macht and Hill that the hydrolysis and fermentation of cane sugar by *Saccharomyces cerevisiæ* is selectively promoted by polarised light (*Proc. Soc. Exp. Biol. and Medicine*, 22, 474, 1925), and lastly, we have Macht's direct confirmation of our own work (*ibid.* p. 473). In the latter experiments, starch solutions containing definite quantities of taka-diastase were exposed to polarised and non-polarised light. The conversion of the starch into sugar took place more rapidly in polarised light than in non-polarised light of the same intensity, and, as Dr. Macht says, the results he obtained fully corroborate our observations.

Prof. Jones says that he has been unable to repeat our observations, and describes his method of observation with a pointolite lamp. We would suggest that the presence of gelatine in his experiments is very undesirable. If we are correct in our assumption that the phenomenon is due to the selective absorption of polarised radiation, then no other inert colloid must be present, as such may completely interfere with the progress of the particular phenomenon to be observed. If an inert colloid be added, then care must be taken that it does not protect the starch by having the same absorptive power towards radiant energy, and further, that it scatters and polarises radiant energy of the correct wave-length. In short, the extraneous colloid, if it is not in correct tune with the starch and its own particular enzyme, will act as a negative catalyst of the reaction. These correct conditions are undoubtedly secured in the natural enzyme, and it is very questionable whether an entirely foreign colloid such as gelatine conforms to these conditions. This most probably accounts for Prof. Jones's negative results, especially in view of the confirmatory evidence we have previously mentioned.

E. C. C. BALY.
ELIZABETH SIDNEY SEMMENS.
The University, Liverpool, and
Bedford College, London,
November 6.

The Blindness of Cave-Animals.

IT is with much diffidence that I take up my pen to reply to the letter of Sir Ray Lankester, which appears in NATURE of November 21. I have been brought up to venerate Sir Ray as the leader of British zoology, and if I cannot claim him as my zoological parent, I can at least regard him as my zoological uncle, for between him and my teacher and friend Adam Sedgwick there always reigned complete sympathy and co-operation.

Sir Ray blames me for having, in a chapter entitled "Zoology" in a book on "Evolution in the Light of Modern Knowledge," come to the conclusion that the inheritance of the results of use and disuse has been the main factor in evolution. He says that this idea is not modern but was put forward by Lamarck a hundred years ago. He also says that he thinks that judgment on the value of Kammerer's experiments should be suspended until they have been repeated, for, as he goes on to say, J. B. S. Haldane points out, that in the past critical repetition of similar experiments has been fatal to the conclusions drawn from them.

Sir Ray then goes on to criticise the theory of inherited disuse as applied to the explanation of the blindness of cave-animals, and to put forward a theory of his own in place of it.

Now I should like to say at once, with reference to Mr. Haldane, that when he thinks fit to publish his criticisms in a recognised scientific journal, instead of in the "Annual of the Rationalist Press Association," which no scientific man is bound to consult and which I, for one, never see, it will give me the greatest pleasure to criticise his criticisms.

As I have pointed out in a review which appears in NATURE of November 28, it is not the lack of evidence which has prevented Lamarckian experiments from bringing conviction, but it is the obsession of minds with the Weismannian complex which has stood in the way and which has caused any attempt, however flimsy, to explain Lamarckian results away, to be accepted as disproving them. For a recent example of this spirit I may refer readers of NATURE to the issue of June 2, 1923, in which a leading English Mendelian, in endeavouring to discredit the evidential value of Kammerer's celebrated specimen of Alytes with the horny pad, says: "but on the palm of Alytes they [the horny callosities] would be as unexpected as a growth of hair on the palm of a man." My comment on this statement is that I have preserved in my laboratory the fore-arms of four male frogs—the first four that I looked at—all of which show the extension of the pad to the palmar surface of the hand.

As Sir Ray Lankester, perhaps, has scarcely been able to keep up with the recent literature bearing on this controversy, he is probably unaware that Kammerer's critical experiments, namely, the handing on to posterity of the effects of the reaction of the skin to coloured surroundings, have been repeated by Durkhen on totally different animals, with the most meticulous care, and that Durkhen's results entirely confirm Kammerer's conclusions. Durkhen's work again has been repeated by Fr. Brecher of Vienna and confirmed.

I am sure that Sir Ray would agree with me that the evidence for evolution is mainly derived from three sources, namely, systematic zoology, palæontology, and embryology. I find that the most distinguished systematists and palæontologists are openly accepting the Lamarckian view; as an embryologist, I myself have been driven to it; and when the experiments just alluded to are taken into account, would Sir Ray not admit that the most modern knowledge on the subject of evolution favoured Lamarck's hypothesis even though that theory was put forward a hundred years ago?

I now come to the special case of the blindness of cave-animals. I am well acquainted with the hypothesis which Sir Ray advances to explain this blindness, namely, that animals with congenital eye-defects stayed in the dark whilst their more gifted brethren escaped into the light. Did I not derive a large part of my early attraction to zoology from Sir Ray's inspiring writings? Nevertheless, I consider Sir Ray's hypothesis unsatisfactory for the following reasons:

(1) The only case in which the cause of blindness in a cave-animal has been analysed is that of the cave-newt, Proteus. Here, as Kammerer has shown, the cause of blindness is not congenital defect, but lack of stimulus to growth, for Proteus can, under proper conditions, produce a perfectly normal eye. Whatever hesitation may remain about accepting Kammerer's results in other matters, there can be no dubiety about his results on Proteus. In common with other zoologists who attended the special meeting of the Linnean Society in May 1923, I saw these large-eyed specimens of Proteus, the most wonderful specimens in my judgment which have ever been exhibited to a zoological meeting.

(2) Congenital eye defects, of course, occur, and I believe that before long we shall discover the causes of them. But they are correlated with general weakness and sickliness of constitution. Microphthalmic rodents, for example, rarely survive. It is most unlikely that such weakly specimens would give rise to a new species.

Sir Ray says that there is no evidence that the eyes of animals bred in the dark diminish in size, and he cites experiments by Payne quoted by Haldane. Payne bred Drosophila for 75 generations in the dark and observed no effect: 75 generations of Drosophila would occupy a little over two years. In an article on "The Inheritance of Acquired Characters," contributed to *Science Progress* in 1921, I showed that there was evidence that the eyes of gammarids, which had lived in pools in deserted salt mines in Austria for two hundred years, had undergone definite reduction, and that this reduction was totally unlike what was met with in congenital eye defect.

E. W. MACBRIDE.

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London, S.W.7.

Carnot's Cycle and Efficiency of Heat-Engines.

THE cycle proposed by Dr. J. S. Haldane (NATURE, August 29, p. 326) as a standard of comparison for steam engine performance can be shown quite readily on a temperature-entropy chart, and thus be directly compared with the Carnot cycle and also with the Rankine-Clausius saturated steam cycle, and the relative efficiencies of the three cycles can be viewed at a glance.

Starting first with water at the lower temperature T_2, heat is added until all the water has been evaporated into steam at a temperature T_1, and in a closed space. This process is shown on the chart (Fig. 1) as the constant volume line *abc*, and the heat added is shown by the area *fabce*. Then follows adiabatic expansion represented by *cd* down to the lower temperature T_2, and finally isothermal condensation along *da*, with rejection of heat measured by the area *edaf*.

The efficiency of the cycle is therefore

$$\frac{\text{area } abcd}{\text{area } fabce} = \frac{A}{A+B}.$$

On the ordinary steam temperature-entropy chart, *ag* being the water line, the line *abc* divides the whole area *fagce* into external energy E and internal energy $A+B$. The Rankine-Clausius cycle being *ag*, *gc*, *cd*, *da*, its efficiency is $\frac{A+E}{A+B+E}$, and this is obviously greater than the Haldane cycle efficiency, since the area E bears a greater proportion to the area A than to the area $A+B$.

The Carnot cycle is simply *ah*, *hc*, *cd*, *da*, and its efficiency is $\frac{A+E+D}{A+B+E+D}$, which, for a similar reason, is greater than $\frac{A+E}{A+B+E}$ for the Rankine-Clausius cycle.

As a numerical example, take 1 lb. of water at a temperature of 140° F. corresponding to 3 lb. per sq. in. absolute back pressure, and let this be evaporated into steam at 341° F. corresponding to an absolute pressure of 120 lb. per sq. in.

From steam tables, the total heat in 1 lb. water at

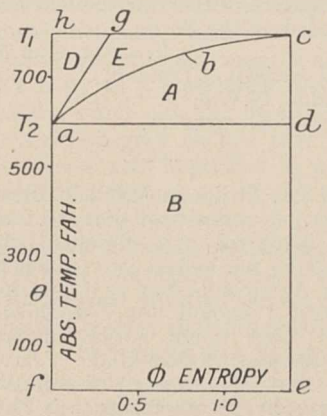

FIG. 1.

341° F. above 32° F. is 1186 B.T.U., the external energy E is 82·1 B.T.U., and latent heat is 874 B.T.U. Hence

$$A+B=1186-(140-32)-82\cdot1=995\cdot9 \text{ B.T.U.}$$

To find area B, first calculate *ad* or ϕ_2.

$$\phi_2=\log_e\left(\frac{341+460}{140+460}\right)+\frac{874}{341+460}=1\cdot3803.$$

Thus

$$\text{area } B=600\times1\cdot3803=828\cdot18 \text{ B.T.U.}$$

and

$$\text{area } A=995\cdot9-828\cdot18=167\cdot7 \text{ B.T.U.}$$

The efficiency is therefore $\frac{167\cdot7}{995\cdot9}=16\cdot7$ per cent.

For the same data, the Rankine-Clausius efficiency is

$$\frac{A+E}{A+B+E}=\frac{167\cdot7+82\cdot1}{995\cdot9+82\cdot1}=23\cdot1 \text{ per cent.,}$$

and the Carnot efficiency

$$=\frac{A+E+D}{A+B+E+D}=\frac{ah}{fh}=\frac{801-600}{801}=25 \text{ per cent.}$$

The chart is drawn approximately to scale for the above data. The higher efficiencies of the two last-named cycles are simply due to the addition of a large proportion of heat at the higher temperature. The Haldane cycle omits this and is therefore of lower efficiency.

H. W. HEATH.

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The London Skull.

IN his most interesting article on the London Skull, in NATURE of November 7, Prof. G. Elliot Smith states that "The deposit in which the human remains were found forms part of the third (or lowest) terrace of the Thames containing the characteristic late Pleistocene fauna . . . presumptive age [of the skull] must be assumed to be later than the Mousterian phase of culture."

On the Geological Survey Maps (one-inch sheet 256 North London; six-inch London 7 SE) the site is shown as Middle Terrace. In the memoirs dealing with the area it is stated that this terrace has yielded late Acheulian types of implements, and that from its surface, overwhelmed by Coombe Rock or Trail, numerous Mousterian implements have been found above, in, and below London. Moreover, the various mammals mentioned by Prof. Elliot Smith as occurring at the Leadenhall Street site are mentioned among those found in this terrace ("Geology of the London District," 2nd ed., 1922, pp. 49-70; "Geology of North London," 1925, pp. 41-49).

If this view of the age of the deposits in which the skull was found is correct, its Neanderthal character, so far from suggesting "the possibility of the survival into Aurignacian times (in Britain) of a stray representative of the species *neanderthalensis*," is quite normal. Being responsible for the maps and memoirs alluded to, I should be glad to know on what grounds Prof. Elliot Smith assigns the deposit to the Low Terrace instead of the Middle, thereby involving himself in a difficulty as to the human species represented by his skull.

C. N. BROMEHEAD.

Geological Survey Office,
14A Parliament Street,
York.

I AM very grateful to Mr. Bromehead for directing my attention to the evidence for identifying the London Terraces. In reply to his query on what grounds I assign the deposit at Lloyd's to the Low Terrace instead of the Middle, I can only say that I have never claimed any competence to decide the geological points at issue; but, as I have already stated in public and in print on several occasions, have taken the opinions expressed when the ulna of the woolly rhinoceros (from the same level in the blue clay at Lloyd's) was exhibited at a meeting of the Zoological Society last March.

The decision of the age of the deposit, concerning which several geologists have written to me, has become of such crucial importance that last week the matter was referred to Prof. Boswell for his advice.

I need scarcely say that if Mr. Bromehead's opinion (which in private correspondence Prof. Sollas and Mr. Reid Moir had already suggested to me) should prove correct, it will facilitate my task of interpretation. For the London skull conforms much more nearly to the Neanderthal type than to the form that is usual in *Homo sapiens*. The fulness of the cerebellum, however, is in sharp contrast with the flattened Neanderthal type. The cranium is as thin as that of a modern woman's. In this respect, however, it agrees with the Neanderthal cranium found in 1911 at La Quina. Moreover, as Prof. Wingate Todd has pointed out (*Anat. Record*, vol. 27, 1924, p. 245), thickness of skull is so variable a feature as to have no decisive value as a specific criterion. Hence the points of difference between the London skull and the Neanderthal type are not necessarily significant. So that, if the blue clay can be shown to

be associated with the Mousterian phase of culture, the anatomical evidence can be interpreted more easily than would be the case if the deposit is Aurignacian.

The paradoxical evidence provided by the anatomical features of the skull renders the determination of the geological age a matter of fundamental importance. Hence Mr. Warren Dawson and I have taken the advice of many authorities in the hope of deciding this issue. Since this letter was written, Mr. Hinton, who examined the remains of the woolly rhinoceros and mammoth from the Lloyd's site last March, has again assured Mr. Dawson that "the blue clay in London is quite definitely post-Mousterian."

G. ELLIOT SMITH.

The Collection of Bryophytes by Scientific Expeditions.

MAY I ask the publicity of your columns for a matter concerning a rather limited branch of natural science, but one which we desire to ventilate as widely as possible in scientific circles?

The following resolution, passed unanimously at the annual meeting of the British Bryological Society held at Ross in August last, to a great extent explains itself:

"That it is desirable that in any future scientific expeditions promoted by British or Colonial public bodies, special attention should be given to the collection of bryophytes, the determination of which should be entrusted to British botanists."

The necessity for such a resolution arises from the fact that in most recent scientific expeditions bryophytes have received the scantiest attention or none at all. As an example may be cited the Mt. Everest Expedition, 1924. Although a special request was made that attention might particularly be paid to the collecting of bryophytes, not a single specimen was brought back by the official scientific staff, although at the altitudes at which most of the encampments were made it was obvious that cryptogamic plants might be expected to form far the highest percentage of the vegetation. This is evidenced by the fact that a certain number of cryptogams were individually collected by one of the climbing members of the expedition, and privately transmitted home, and these proved of great scientific interest (*cf. Journ. of Bot.*, 1925, pp. 189, 221)—including a moss from considerably the highest altitude from which any moss has hitherto been collected.

A recent scientific expedition to Australia, the West Australian and Islands Expedition, under Capt. Wilkins, sent out under the auspices of several of the principal scientific institutions and societies of Great Britain and Australia, returned with but a single example of the lower cryptogamous plants—a block of fossil diatomaceous earth. Bryologists have repeatedly the tantalising experience of hearing from returned explorers of the wealth of bryophytic vegetation traversed by them—lantern slides being sometimes especially prepared, for their particular delectation or exasperation, to illustrate the "dense masses of arboreal mosses" through which an expedition passed—only to find that among the botanical collections brought home the bryophytes are conspicuous by their absence.

The older botanical explorers knew better—Hooker in the Antarctic, Spruce on the Amazon, Schweinfurth in Africa, Wallich in Asia, and a host of others—and our knowledge of the world flora and of the factors of geographical distribution has been vastly increased thereby.

The facility of their collection further justifies our claim, since no plants demand less in the way of space or preparation. They simply require drying; and they may be usefully employed in filling up interstices and acting as packing for other specimens.

These arguments might easily be multiplied, but they would make a further demand on your space which would be, I fear, undue, and I hope superfluous.

H. N. DIXON.

17 St. Matthew's Parade,
Northampton.

The London Zoological Society's Aquarium.

IN NATURE of November 21, p. 767, in a report of the recent ornithological meeting in Berlin, "E. H." states that the Berlin Aquarium was "the model from which the larger London Aquarium has been built." This is entirely erroneous. Certainly we knew of and had inspected the Berlin Aquarium as well as many others whilst making our plans, but I do not know of any single feature, either mechanical or decorative, which we based on the Berlin Aquarium.

P. CHALMERS MITCHELL.

Zoological Society of London,
London, N.W.8,
November 23.

I AM glad Dr. Chalmers Mitchell corrects an error in my report. I understood that Mr. Boulenger had thoroughly inspected and measured the tanks in Berlin, which to me looked very much like those in the London Aquarium—but as I am not an expert on aquariums, I should not distinguish differences very clearly, and would notice similarities in all modern institutions of that kind. I have never had any doubt that the London Aquarium has great improvements on all others, as it is natural to improve on former establishments of the kind, when building a new one, by making use of the experience of others.

E. H.

Cyclops robustus, G. O. Sars.

Cyclops robustus is given by Prof. Sars as one of the rarer species, and to the best of my knowledge it has not been recorded previously for the British Isles.

Last July several specimens occurred in some tubs outside the biological laboratory at Marlborough College. The tubs in question are kept for the refuse from pond-life study. Some time afterwards, as the result of a fairly prolonged search, several ponds were found in Savernake Forest containing this species.

The reason why this species has not been recorded in the British Isles before must be, I think, that it has been overlooked on account of its resemblance to *Cyclops lucidulus*, Koch. That *Cyclops robustus* is really widely distributed in the British Isles is almost certainly proved by the fact that I found it so far north as Roineval in the Isle of Skye in September last.

It is interesting to note that Prof. Sars in "Crustacea of Norway" (vol. 6, p. 46) states that he has only found this species, in Norway, on the borders of the larger lakes. I have only found it in quite small ponds, if not puddles, especially those containing Sphagnum. Dr. W. Arndt has also found it in ponds in Bulgaria (*Zool. Anzeiger*, vol. 61, p. 298), though his specimens seem to differ somewhat from the original type.

A. G. LOWNDES.

Marlborough College, Wilts.,
November 20.

The Nature of Man's Structural Imperfections.[1]

By Sir ARTHUR KEITH, F.R.S.

I.

BETWEEN the activities of Archdeacon Paley and those of Élie Metchnikoff lies the greater part of the nineteenth century. At the beginning of that century we find the Archdeacon extolling the perfections of the human body—just as Celsus had done sixteen centuries before him.[2] By the close of the nineteenth century the alert and fearless brain of Élie Metchnikoff had discovered, or believed it had discovered, that the human body was blemished by many imperfections. The evangelist of this new and startling doctrine approached the study of man's body by an untrodden pathway, one made possible by the advancing science of his day. On his arrival at the Institut Pasteur in 1888, being then forty-three years of age, he set himself to investigate the means by which the human body combats and keeps at bay the swarming hosts of micro-organisms which find a natural habitat in its internal passages and recesses. He saw man's body as a battlefield—the scene of a perpetual warfare—and as his investigations proceeded, the conviction grew on him that the chances of the body's success were imperilled by a heritage of structures which had become out-of-date and useless. In the Wilde Lecture given before the Literary and Philosophical Society of Manchester, on April 22, 1901, he declared that man "was being killed by his intestinal flora," and that his great intestine had not only become useless but was also a positive and continual menace to the rest of his body. He believed that the stomach itself, and also part of the small intestine, could be dispensed with. Early in 1903 appeared "Études sur la nature humaine,"[3] in which Metchnikoff greatly extended the list of man's structural imperfections.

Between the times of Paley and of Metchnikoff lie three great discoveries, and we must take note of them if we are to understand how it was possible for one to praise the perfection of man's structure at the beginning of the nineteenth century and the other to condemn its imperfections at the end. There was first the discovery that man's body was an aggregate or society of living microscopical units; it was Metchnikoff's fortune to approach the study of man's highly complex body through the simpler societies represented by the bodies of the lower invertebrates; it was thus he came by his discovery that certain units of such societies retain their freedom, thus permitting them to serve as scavengers or phagocytes. In the second place, there was Darwin's discovery; Metchnikoff was a convinced evolutionist. He therefore presumed that the alimentary outfit which served in an anthropoid phase of human evolution must be ill-adapted to deal with the dietary of civilised man. There was in the third place Pasteur's discovery, and so far as Metchnikoff's outlook was concerned, this was the most potent of the three. It was under the influence of Pasteur's discoveries that Metchnikoff came to think that the destiny of man lay in the issue of the everlasting contest which went on between the living tissues of his body and the invading hosts of micro-organisms which threatened them. It is noteworthy that of the three men—Darwin, Pasteur, and Metchnikoff—who revolutionised in the 19th century our conception of man's body, and of the struggles to which it is subjected, not one of them was a professed anatomist; the anatomist stood too near to the subject of his study to see it in its true perspective.

Twenty-two years have come and gone since Metchnikoff's studies on "La nature humaine"[4] first appeared, and I propose in this lecture to ascertain how far his doctrines of man's structural imperfections and functional disharmonies have stood the test of time. His thesis presumed that Darwin's theory of man's origin was true; that presumption has been supported by every discovery of the present century, and such evidence as we now have justifies us in believing that the rate of man's evolution has been more rapid than has hitherto been supposed.[5] We realise to-day, more precisely than was possible when Metchnikoff wrote, that the most critical chapter in man's long history opened with the discovery of agriculture, a discovery of but yesterday if we reckon time on a geological scale. Agriculture revolutionised the conditions of human life; it made modern civilisation possible. We have reason to believe that this revolution in the condition of man's life was initiated either in Mesopotamia, Egypt, or adjacent lands not more than 8000 years ago. It is certainly not more than 5000 years ago since agriculture began to be practised in Western Europe. The vast majority of the people of the British Isles, probably 90 per cent. of them, are the descendants of men and women who, 200 generations ago, were dependent on the natural but precarious harvest which is provided by shore, river, forest, and moorland. City life is a new experiment for Europeans; most of us who live in London, if we could go back twenty generations, would find an ancestry which was living on the soil and of the soil; and now the poorest of us can add to our dietary produce brought from the ends of the earth. The alimentary system which was evolved to meet the needs of our primitive ancestors has now to accommodate itself to a modern dietary.

Beyond a doubt civilisation is submitting the human body to a vast and critical experiment. It is not only the alimentary system which is being subjected to new conditions; the bony and muscular framework of our bodies are also being subjected to novel stresses. Of the present manhood of Britain, half earns its bread by muscular labour; the other half lives sedentary lives. Our forefathers when they arrived in Western Europe were hunters; their bodies were unaccustomed to either manual labour or an indoor life; under the

[1] The Lloyd Roberts Lecture delivered to the Royal Society of Medicine on November 16.

[2] See "Evolution of Anatomy," by Dr. Charles Singer (1925), p. 50.

[3] An English translation, edited by Dr. P. Chalmers Mitchell, was published in 1904 under the title "The Nature of Man" (Heinemann).

[4] In 1907 Metchnikoff published a further work, of which an English translation appeared in the same year, edited by Dr. P. Chalmers Mitchell, under the title "The Prolongation of Life." In this Metchnikoff replied to his critics and produced more evidence in support of his thesis. Sir W. Arbuthnot Lane formed the opinion that the great intestine was a useless and dangerous structure independently of Metchnikoff; so also did Prof. Barclay Smith (see an article on the nature of the caecum and appendix by the present lecturer in the *Brit. Med. Journ.* 1912, vol. 2, p. 1599).

[5] See "The Adaptational Machinery concerned in the Evolution of Man's Body," NATURE (Special Supplement), August 18, 1923, p. 257; and "Concerning the Rate of Man's Evolution," NATURE, August 29, p. 317.

stress of civilisation the hunter's body has to serve modern needs. It says much for the adaptability of the human body that it stands these stresses so well as it does. Dr. J. D. Comrie,[6] on examining 10,000 recruits for the army, found that 363 of them suffered from hernia and 113 from flat foot. Such breakdowns in the supporting system of the body do not occur with this frequency among hunting peoples. Civilisation has laid bare some of the weak points in the human body, but the conditions which have provoked them are not of Nature's ordaining but of man's choosing.

If modern civilisation is making new demands on our bones, muscles, and nerve controls, it is otherwise with another important system of our bodies. As our manner of living increases in comfort, the calls on our heat-regulating mechanism become fewer in number and less urgent in character. Our primitive forefathers lived in the open; their bodies, unhoused and scantily clad, were exposed to sun, rain, wind, and storm. Such a mode of life throws an increasing burden on the machinery which regulates body temperature—on skin, on respiratory mucous membrane, and on that elaborate system of reflexes which control the rate of internal combustion. Modern civilisation, so far as temperature is concerned, tends to make the human body a hot-house plant.

Metchnikoff perceived that civilisation had plunged man's body into a new environment, and that the rate of its progress had far outstripped the power of adaptional response which had carried man so far beyond the anthropoid stage. A belief grew within him—almost a grudge—that Nature was letting man down. He brought against the evolutionary powers which preside over the destiny of man both sins of omission and sins of commission. We shall deal with a sample of each. The first complaint on his list of omissions is that we have not shed from our skins the last remnants of an anthropoid pelage; hair on the body, he held, was useless and a source of disease. Whether or not a completely hairless body is desirable we may leave as a moot point; a hairless breed of dogs has been produced and no doubt a hairless race of man could be evolved. In this matter the Caucasian has been outstripped by the Negro and by the Mongol, the most hairless of races. It is more to the point to inquire how man has come by a comparatively hairless skin, and in the solution of this problem we have been making some advance. A hairless condition became possible with the evolution of the higher vertebrates; a fœtus in the womb draws its heat from the mother's body; it has no need of a hairy covering until the period of birth arrives. There is in the Museum of the Royal College of Surgeons of England a chimpanzee fœtus in the eighth month of development; the hair of its head and body has reached a stage identical with that of a newly-born child. A stage of development which is evanescent in the fœtal anthropoid has become permanent in us. We have come by a new character through the inheritance of one evolved in fœtal life. Many of our structural features have come to us in this way.[7] The base of the human skull is greatly flexed. In the fœtal stage of all mammals the basi-cranial axis is bent, but in man only has this character been carried into adult years. Fœtal inheritance becomes more and more possible for man because civilisation tends to make man's world into a protective womb.

As an example of a sin of commission, the introduction of a new and useless structure to the human body, Metchnikoff cites the case of the hymen. It is scarcely true to describe, as he does, the hymen as a new structure; it is present at a certain stage in the embryonic life of every higher mammal; it is only in the human species that it persists and forms a definite and substantial structure in the fully formed body. The hymen provides another example of the human body coming by a new character by retaining and modifying a structure which made its first appearance during embryonic or fœtal life. When we seek to explain its use we must enter the purlieus of psychology, for round man's sense of sex has grown up a strange hinterland in his subconscious mind. Metchnikoff described the hymen as "an unpleasant impediment," but love, as the world has long recognised, thrives on impediments. The human prepuce, although not a new structure, was, in Metchnikoff's opinion, a useless and dangerous one; circumcision in one generation does not diminish the completeness of its development in the next. In this the prepuce resembles the hymen. Indeed, Metchnikoff said of the latter structure that the only purpose it had ever served was "the overthrow of the dogma of the inheritance-acquired characters."

The examples which I have cited above of the failure of man's body to adapt itself to present requirements are of little more than academic interest, but when Metchnikoff applied his analytical genius to the problems of man's alimentary system, he carried us into the realms where thought becomes the guide to action. "It would be no longer rash to say," so he wrote in 1903, "that not only the rudimentary appendix and the caecum, but the whole of the human large intestine are superfluous and that their removal would be attended with happy results." Since Metchnikoff penned this sentence, the operation of complete colectomy has been performed on many thousands of men and women, but I do not think that even the surgeons who have performed this operation most frequently and most successfully would maintain that a man or woman who has been rendered colonless enjoys that moderate share of health which falls to the average intact individual. If a finger becomes permanently fixed in an awkward position, the hand is improved by the amputation of the offending digit, but the relief thus gained does not restore the hand to its original capacity. The relief afforded by colectomy is of the same kind; the results of that operation in no wise bear out Metchnikoff's doctrine that the colon has become a superfluous organ in man's body. On the other hand, we have only to consult the pages of the medical press, to listen to tales which reach our ears daily, to note the ever-growing demand for patent purgatives, to be convinced that there is, as Metchnikoff maintained, a grave disharmony between the functional capacities of our great intestine and the dietary which modern civilisation has compelled us to adopt. The way out of our difficulties is not to call the colon a useless organ,

[6] *Lancet*, 1919, 2, p. 959.

[7] Prof. Louis Bolk, "The Part played by the Endocrine Glands in the Evolution of Man," *Lancet*, 1921, vol. 2, p. 588. See also Keith, "The Evolution of Human Races in the Light of the Hormone Theory," *Johns Hopkins Hospital Bulletin*, 1922, vol. 33, p. 195.

a "sewage pipe," a "cesspool," but to discover its original purpose and ascertain how far we can modify our mode of living to suit its inherited capacity. What that capacity is we have yet to discover, for we have no complete or exact knowledge of the uses of the great intestine in any animal whatsoever. So far as the human organ is concerned, surgery has stepped far in advance of physiology.[8]

Since Metchnikoff first promulgated his belief that the appendix, cæcum, and colon had become superfluous organs in man's body, our knowledge concerning the evolution of these structures, and of certain conditions which regulate their action, has increased. That increase of knowledge rehabilitates the ancient belief that Nature in her evolutionary mood exercises not only a surprising ingenuity but also the strictest economy. The ferments and catalysts elaborated by plants for their own use were made to serve in the animal body as vitamins. How necessary such substances are for the proper working of the great bowel has been shown by the recent researches of McCarrison [9] and of Cramer.[10] It was for the purposes of economy that the great bowel came into existence. In fishes, the earliest vertebrate forms known to us in the living state, potent digestive juices have to be produced at the expense of body tissues; with the evolution of land-living, air-breathing forms, much of this expenditure was saved by the utilisation of bacterial digestion. The great bowel was added to the original intestine for this purpose, the oldest part of this annex being the cæcum and appendix. The great bowel as we know it in fishes is a mere diverticulum from the hinder end of the gut; it takes no part in the digestion of food. Its epithelium forms a glandular structure which has all the appearance of an organ designed for the supply of an internal secretion.[11] That secretion, whatever it may prove to be, is carried to the liver by the inferior mesenteric vein.

In the mucous membrane of the human great bowel, there are embedded in a stratum of reticular tissue—of reticulo-endothelium—some 15 millions of minute test-tube glands—the glands of Lieberkühn. No one who has noted the structure and setting of these glands, and the fine changes which their cells undergo in the course of action, can believe that their sole function is to supply a lubricating fluid for the intestine; they have all the appearance of also supplying an internal secretion, and the evolutionary history of the colon favours such an inference.[12] The reticular stratum of the colon, which Dr. Scott Williamson [13] regards as the most important constituent of its mucous membrane, and in this I agree with him, represents a spleen of considerable size. Indeed, just as the liver and pancreas represent extrusions of highly specialised parts of the intestinal epithelium, the spleen represents a specialisation of the reticulo-endothelium of the alimentary canal; in cyclostomes [14] the spleen is still intra-intestinal. Nor must we forget how greatly the large intestine is linked to the central nervous system—both by afferent and efferent pathways. When we take all these considerations into account, we must conclude that the great bowel of man is not a useless or superfluous organ, but one which we, in our ignorance, are maltreating.

[8] The reader will find a summary of the anatomical evidence relating to the nature of the appendix, caecum, and great bowel by the lecturer in the *British Med. Journ.*, 1912, vol. 2, p. 1599.

[9] Lt.-Col. R. McCarrison, "Faulty Food in Relationship to Gastro-intestinal Disorders," *Lancet*, 1922, vol. 1, p. 207. Other references to Lt.-Col. McCarrison's researches will be found in this paper.

[10] Dr. W. Cramer, *Lancet*, 1921, vol. 2, p. 1202; 1924, vol. 1, p. 636.

[11] Dr. Doris R. Crofts, *Proc. Zool. Soc.*, 1925, Part I., pp. 101, 170.

[12] I have not mentioned the excretory function of the colon. This has been investigated by Dr. Owen T. Williams, see *Brit. Med. Journ.*, 1912, vol. 2, p. 1281.

[13] *British Journal of Surgery*, 1914, vol. 2, p. 306.

[14] J. Mawas, *C.R. Acad. Sci.*, 1922, vol. 174, pp. 889, 1041.

(*To be continued.*)

High Frequency Rays of Cosmic Origin.[1]

By Dr. R. A. MILLIKAN,

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IT was so early as 1903 that the British physicists, Rutherford and McLennan, noticed that the rate of leakage of an electric charge from an electroscope within an air-tight metal chamber could be reduced by enclosing the chamber within a completely encircling metal shield or box with walls a centimetre or more thick. This meant that the loss of charge of the enclosed electroscope was not due to imperfectly insulating supports but must rather be due to some highly penetrating rays, like the gamma rays of radium, which could pass through metal walls as much as a centimetre thick and ionise the gas inside.

In view of this property of passing through relatively thick metal walls in measurable quantity, the radiation thus brought to light was called the "penetrating radiation" of the atmosphere and was at first quite naturally attributed to radioactive materials in the earth. But in 1910 and 1911 it was found that it did not decrease as rapidly with altitude as it should upon this hypothesis. The first significant report upon this point was made by a German physicist, Gockel, who took an enclosed electroscope up in a balloon with him to a height of 13,000 feet and reported that he found the "penetrating radiation" about as large at this altitude as at the earth's surface, despite the fact that Prof. Eve, of McGill University, had calculated that it ought to have fallen to half its surface value in going up 250 feet.

In 1912–14 two other German physicists, Hess and Kohlhörster, repeated these balloon-measurements of Gockel's, the latter going to a height of 9 km., or 5·6 miles, and reported that they found this radiation decreasing a trifle for the first two miles and then increasing until it reached a value at 9 km., according to Kohlhörster's measurements, eight times as great as at the surface.

This seemed to indicate that the penetrating rays came from outside the earth, and were therefore of some sort of cosmic origin. The War put a stop the world over to further studies of this sort, but so soon as we could get the proper instruments built after the War in the newly equipped Norman Bridge Laboratory of Physics, I. S. Bowen and myself went to Kelly Field,

[1] Address delivered before the National Academy of Sciences, Madison, Wis., U.S.A., on November 9.

near San Antonio, Texas, with four little recording electroscopes which we succeeded in the spring of 1922 in sending up in sounding balloons to almost twice the heights which had previously been attained. The highest flight reached the altitude of 15·6 km., or nearly 10 miles.

These instruments were interesting in that, though they were built to hold 300 cubic centimetres of air at 150 pounds pressure, and were provided each with a recording barometer, thermometer, and electroscope, also with three different sets of moving photographic films and the necessary driving mechanism, the total weight of the whole instrument was yet but 180 grams, or about 7 ounces.

In these experiments we expected, if the results previously reported were correct, to find very large rates of discharge; for our instruments went up to such heights that nine-tenths of the atmosphere had been left beneath them, and only one-tenth was left to cut down, by its absorption, the intensity of the hypothetical rays entering from outside. The results were contrary to this expectation. They proved conclusively, however, in agreement with the observations of Hess and Kohlhörster, that the penetrating radiation was greater at great altitudes than at the surface, but that the amount of the increase was not more than a fourth of that predicted from the results of the German observers. (Two years later they reduced their estimates, after further experiments, so that they were no longer in conflict with our measurements.)

Variation of Absorption with Altitude.

Since the origin of the rays was still uncertain, with indications in favour of some cosmic source, Dr. Russell Otis and myself felt that the next step was to find out how penetrating the rays were; and since they were weaker at the surface than higher up, we went to the top of Pike's Peak in the summer of 1923, carrying up 300 pounds of lead and a big 6 ft. × 6 ft. × 6 ft. water tank for the sake of making absorption measurements on such rays as were found at that altitude.

We found that though our electroscopes discharged twice as fast on Pike's Peak as at the altitude of Pasadena, the rays were cut down so fast by our absorbing screens that it was certain that the greater part of them were not much, if any more, penetrating than the ordinary gamma rays emitted by radium. We found, further, that the rate of discharge of our electroscope was decreased by 10 per cent. by a heavy snowstorm which occurred during the week in which we were on the peak. This showed conclusively that the chief part, at least, of the rays with which we were experimenting on the peak were of local origin, and that they might be due to radioactive matter which in some unknown way got into the upper regions of the atmosphere.

The search for the cause of the increase with altitude in the intensity of these soft gamma-like rays became, therefore, quite as interesting as the question of the existence of a very penetrating radiation of cosmic origin, since this latter would produce at the most but a fraction, and no large fraction either, of the observed increase between Pasadena and Pike's Peak. Mr. Harvey Cameron and I therefore planned experiments for the summer of 1925 which were designed (1) to settle definitely the question of the existence or non-existence of a small, very penetrating radiation of cosmic origin, and (2) to throw light on the cause of the variation with altitude of the softer radiation of the gamma ray type which we had found more than twice as intense on Pike's Peak as at Pasadena.

High Penetrating Power.

To bring to light the very penetrating radiation, if it existed, it was necessary to find at very high altitudes very deep snow-fed lakes, for any radioactive contamination of the water through its seepage through the earth would vitiate the results obtained by sinking electroscopes to different depths beneath the surface of the lake.

We chose for the first experiment Muir Lake (11,800 feet high), a beautiful body of water hundreds of feet deep just under the brow of Mount Whitney, the highest peak in the United States. Here we worked for the last ten days in August, sinking our electroscopes to various depths down to 60 feet. Our experiments brought to light altogether unambiguously a cosmic radiation of such extraordinary penetrating power that the electroscope reading kept decreasing down to a depth of 45 feet below the surface. The atmosphere above the lake was equivalent in absorbing power to 23 feet of water, so that we had found rays, coming into the earth from outer space, so penetrating that they could pass through 45 plus 23 equalling 68 feet of water, or the equivalent of 6 feet of lead, before being completely absorbed. This represents rays much harder (more penetrating) than any which had before even been imagined. The most penetrating X-rays which we produce in our hospitals cannot go through half an inch of lead. Here were rays originating somewhere out in space at least a hundred times more penetrating than these.

Further, high penetrating power means, according to modern physics, simply high frequency or short wave-length. Our experiments indicate, then, that there is a region of frequencies as far up above the X-ray frequencies as are these latter above the frequencies of light waves. They show quite definitely, too, that these highest frequency rays are not homogeneous, but have a measurable spectral distribution, the shortest waves which we observed being a little less than twice the frequency of the longest, for the rays which we actually observed in Muir Lake changed hardness or frequency as they were filtered through greater and greater thicknesses of water, just as X-rays are successively hardened by passing through successive layers of lead. The experiments with the sounding balloons indicate that the frequencies of these cosmic rays do not extend over into the X-ray region of frequencies, else we should have obtained larger discharges in the experiments with sounding balloons when nine-tenths of the atmosphere had been left beneath us.

Further, we obtained good evidence that these cosmic rays shoot through space in all directions, this evidence being found in the fact that we could observe no change whatever in their intensity throughout day or night.

All the results obtained in Muir Lake were checked with wonderful completeness by another set of observa-

tions in another snow-fed lake—Arrowhead Lake—300 miles away from Muir, 7000 feet lower, and equally deep, where the Arrowhead Lake Development Company kindly put all their facilities at our disposal. Indeed, the absorbing power of the atmosphere between the elevations of Muir and Arrowhead Lakes is the equivalent of about two metres of water, and as a matter of fact, every reading in Arrowhead was practically identical with one taken in Muir at a depth two metres lower.

Origin of High Frequency Rays.

We can draw some fairly reliable conclusions as to the origin of these very penetrating and very high frequency rays. The most penetrating rays that we have known anything about thus far, the gamma rays of radium and thorium, are produced only by nuclear transformations within atoms. This means that they are produced by the change of one atom over into another atom, or by the creation of a new type of atom. It is scarcely possible, then, to avoid the conclusion that these still more penetrating rays which we have here been studying are produced similarly by nuclear transformations of some sort. But these transformations must be enormously more energetic than are those taking place in any radioactive changes which we know anything about. For the frequency of any emitted ray is, according to our present knowledge, proportional to the energy of the subatomic change which gives birth to it. We can scarcely avoid the conclusion, then, that nuclear changes having an energy value perhaps fifty times as great as the energy changes involved in observed radioactive processes are taking place all through space, and that signals of these changes are being sent to us in these high frequency rays.

The energy of the nuclear change which corresponds to the formation of helium out of hydrogen is known, and from it we have computed the corresponding frequency and found it to correspond closely to the highest frequency rays which we have observed this summer. The computed frequencies of these rays also correspond closely to the energy involved in the simple capture of an electron by a positive nucleus. It is possible that this phenomenon is actually going on all through space. This is, I think, the most probable source of these rays. It is true that the formula underlying this computation of the frequencies of these rays from their absorption coefficient is of uncertain validity. It is a formula, nevertheless, that works well in the frequency range in which we can get independent checks upon it, namely, in that of the X-ray field and the gamma ray field.

According to this formula, the wave-length of the shortest waves which we have here investigated is 0·0004 Ångstroms, or but one-fiftieth of that of the hardest gamma rays heretofore known, and but one-ten millionth that of ordinary light. The longest wave-length which we have found is about five-thirds of the shortest, or 0·00067 Ångstroms.

When these extraordinarily high frequency rays strike the earth, according to the now well-established Compton effect, they should be transformed partially into soft scattered rays of just about the hardness, or the wave-length, of the soft rays which we have actually observed on Pike's Peak and Mount Whitney. The reason these soft rays were more plentiful on the mountain peaks than at Pasadena would then be found simply in the fact that there are more than twice as many of the hard rays to be transformed at the altitudes of the peaks than at that of Pasadena. This seems to be the solution of the second of our summer's problems.

But how can nuclear transformation, such, for example, as the formation of helium out of hydrogen or the capture of an electron by a positive nucleus, be going on all through space, the resulting rays coming apparently as much from one direction as from any other, and certainly not a whit more plentifully from the direction of the sun than from that diametrically opposite to it, as evidenced by the entire equality of our midday and midnight observations? The difficulty is not so insuperable, in view of the transparency even of large amounts of matter for these hard rays, combined with Hubble's recent proof at the Mount Wilson Observatory that some of the spiral nebulæ are at least a million light years away. The centres at which these nuclear changes are taking place would then only have to occur at extraordinarily widely scattered intervals to produce the intensity of the radiation observed at Muir Lake.

The only alternative hypothesis to that above presented, of high frequency rays traversing space in all directions, might seem to be to assume that the observed rays are generated in the upper layers of the atmosphere by electrons shooting through space in all directions with practically the speed of light. This hypothesis might help in interpreting the mysterious fact of the maintenance of the earth's negative charge, but it meets with insuperable obstacles, I think, in explaining quantitatively the variation with altitude of the ionisation in closed vessels. In any case, this hypothesis is, in its most important aspect, very much like the one represented above, for it, too, fills space with rays of one sort or another travelling in all directions with the speed of light. From some such conception as this there now seems to be no escape. Yet it is a conception which is almost too powerful a stimulus to the imagination. Prof. MacMillan, of Chicago, will wish to see in it evidence for the condensation into matter, out somewhere in space, of the light and heat continually being radiated into space by the sun and stars, and the psychists will be explaining all kinds of telepathic phenomena by it.

In any event, our experiments seem to point to the following conclusions:

(1) That these extraordinarily penetrating rays exist;

(2) That their mass absorption coefficient may be so high as 0·18 per metre of water;

(3) That they are not homogeneous, but are distributed through a spectral region far up above X-ray frequencies—probably 1000 times the mean frequencies of X-rays;

(4) That these hard rays stimulate, upon striking matter, softer rays of about the frequency predicted by the theory of the Compton effect;

(5) That these rays come into the earth with equal intensity day and night and at all hours of the day or night, and with practically the same intensity in all directions.

Current Topics and Events.

SOME progress is being made with the unifying of the electric supply undertakings in Great Britain, and electricians are beginning to look forward to larger generating stations and higher electric pressures of distribution. This is reflected by the activity of research in connexion with the dielectrics of cables for use with very high pressures. Both the Institution of Electrical Engineers and the Junior Institution of Engineers have discussed papers on this subject this year. In both these papers the progressive nature of a breakdown when it occurs is emphasised. There seems, however, to be some confusion as to what physicists mean by the electric strength of a homogeneous dielectric. This electric strength varies with temperature and mechanical pressure. The so-called "time lag" before the insulating material breaks down is due to the fact that its temperature is gradually rising and its electric strength is therefore diminishing. A spark or a brush discharge occurs when the electric strength becomes less than the maximum applied electric stress. To attempt to express "time lag" by a formula seems to us to be waste of time. There are many miles of 33,000-volt cable in use in Great Britain and some of them have been in uninterrupted operation for more than six years. Mr. Emanueli of the Pirelli Cable Company said that a cable had been in successful operation in Italy for eighteen months at 130,000 volts. He attributed its successful operation to the fact that air and gas bubbles had been entirely eliminated from the insulation. The manufacture of cables which will withstand these enormous pressures is a very considerable step in advance, and, provided that the price is reasonable, it will affect very appreciably the trend of the development of electrical supply all over the world. The cost of the transmission cables in any large scheme of electricity supply is always the major part of the capital cost. As raising the pressure largely reduces this cost, it will cheapen the supply to the public.

THE problems of transport in tropical Africa, especially in relation to cotton-growing, are discussed in a memorandum prepared by the Mechanical Transport Sub-Committee of the Empire Cotton-growing Corporation. After a general survey of means of transport, it is pointed out that transport facilities are unlikely to develop along the same lines as in Great Britain. A network of branch railways or of modern macadamised roads is out of the question in the great spaces of thinly inhabited and sparsely cultivated Africa. Even if the volume of traffic warranted the construction of good roads, their upkeep would be prohibitive in regions of torrential rain. In the belief that for many years to come the roads in Africa will be unmetalled, the chief problem is to find what type of vehicle will inflict the least damage on the roads. With this end in view it is essential to maintain a low pressure per square inch of the road surface. After discussing the number, width, and diameter of wheels, the sub-committee considers that the caterpillar or track system is a preferable alternative to the use of wheels. The most promising development of this device is the "half-track" system in which the front wheels are retained for steering purposes and the rear wheels are replaced by a flexible double track system. Trials with certain vehicles constructed on this principle hold out hope that the solution of the transport problem lies in that direction, although many improvements in the vehicles are still required.

IN order to commemorate the great services made to polar exploration by the late Dr. W. S. Bruce, leader of the Scottish National Antarctic Expedition, a fund has been raised by subscription, the proceeds of which will be awarded biennially "for some notable contribution to Natural Science, such as to zoology, botany, geology, meteorology, oceanography and geography, the contribution to be in the nature of new knowledge, the outcome of a personal visit to the polar regions on the part of the recipient." The award will consist of a medal, inscribed "Exploration of Polar Regions" and on the reverse "For Valuable Services," modelled on that designed by Dr. Bruce to commemorate the return of the *Scotia*, with in addition a sum of money. In the making of the award, preference will be given, other things being equal, to an explorer of Scottish birth or origin, and to one at the outset of his career as an investigator. The Royal Society of Edinburgh has been asked by the subscribers to accept and has accepted custody of the Bruce Memorial Fund, and awards will be made by a joint committee representing that society, the Royal Physical Society and the Royal Scottish Geographical Society. The first award will be made in 1926. For the purpose of increasing the money award of the prize, subscriptions may still be sent either to Mr. A. N. G. Aitken, S.S.C., 37 Queen Street, Edinburgh, or to the Treasurer of the Royal Society of Edinburgh.

IN a paper on the future of engineering, by Dr. W. B. Parsons, which appears in the August number of the *Journal of the Franklin Institute*, stress is laid on the fact that engineering as we now know it is little more than a century old. The main characteristics of the present epoch are the substitution of mechanical for animal power and the application of mechanical power to secure results obtainable in no other way. If the use of mechanical energy were abolished our much-vaunted civilisation could scarcely recover from the shock. The energy that we use and on which our civilisation mainly rests comes from the burning of coal and oil. From 1800 to 1860 the consumption increased ten times, from 1860 to 1920 it again increased ten times. More than a ninth of the total consumption of fuel is now due to oil. If we assume that the consumption doubles every 16 years, then in a little more than 200 years our total reserves will be exhausted. It is certain, therefore, that the rate of consumption of fuel cannot go on

increasing at the present rate and that the cost will go on increasing. Using excellent steam engines, only about 20 per cent. of the energy of combustion is converted into useful work and very little increase is possible with steam. To utilise our water power resources fully, we need some economical method of storing energy. This is one of the pressing problems of hydro-electric engineering. It is estimated that more than one-third of the potential horse-power of the world is to be found in Africa. When energy can be stored and transported or transmitted, the great sources of water power existing in the tropics would become available. But the total water power in the world falls far short of its needs. Atomic energy, the heat of the earth, tides and waves at present offer very little hope. Doubtless, as the need becomes more pressing, wind-mills, especially in those places where the trade winds flow fairly steadily, will be largely utilised. Solar heat appears, however, to be the most promising source. There is an urgent call to engineers with the aid of physics and chemistry to invent a more efficient power-producing engine than the steam generator, and a device to store energy that can be much more readily utilised than the electric accumulator.

"THE first epistle of Henry the Chemist to the Uesanians" is the somewhat bizarre title of a characteristic article by Prof. H. E. Armstrong printed in the September issue of the American *Journal of Chemical Education*. Beginning with a very long epigraph, after the manner of a Pauline epistle, the author proceeds to express his opinions on topics connected with the ethics of belief, education, literature, chemistry, and culture. His incisive style reminds one of Shaw and Chesterton, who by wealth of hyperbole and paradox, lame aphorisms, and parodied proverbs, know well how to arrest attention, and also of the late Lord Morley, who, when asked for his opinion on the prose of Carlyle, replied that he preferred the English language. Prof. Armstrong denounces the modern Press, present-day teaching of science, the poor literary value of scientific writing, and the absence of cultural value in the science of to-day; but he reserves the vials of his wrath for the adherents of the hypothesis of ionic dissociation, who above all others appear to him to sin most against the Pauline injunction of "proving all things, and holding fast that which is good," the freedom to do which, he says, is the only intellectual freedom worth having. Through this excursive "epistle" runs a serious *leitmotif* that will appeal to all, namely, that dogmatism in science is the negation of science, a truth which is of wider applicability than is sometimes assumed.

A LONG-FORGOTTEN hoax and a controversy almost equally overwhelmed by oblivion is recalled by Dr. L. A. Gausman in an article, "The Figured Stones of Würzburg," which appears in the *Scientific Monthly*, vol. 21, No. 5. In the early years of the eighteenth century, when the origin and significance of fossils was being hotly debated, Dr. Johann Bartolomaeus Adam Beringer, doctor of medicine and philosophy and professor of natural philosophy in the University of Würzburg, publicly committed himself to the belief that fossils were merely the capricious fabrications of God, who had committed them to the earth for some inscrutable purpose. Thereupon students and others made a number of fantastic "fossils" of clay, which they buried on a hill near Würzburg. They were discovered by Prof. Beringer and accepted as genuine and as supporting his views. The ground was then further "salted" with still more fantastic forms, inscribed in Hebrew, Babylonian, Syrian, and Arabic. In 1726, Prof. Beringer, notwithstanding the remonstrances of his friends, published his "results" in a quarto "Lithographiæ Wirceburgensis," in which his methods of investigation and safeguards against error and fraud were fully described. The book was received with universal ridicule, and the author died shortly after, a broken man.

THOSE who regret the fact that a site of such importance in the history of palæontological and archæological studies in Great Britain as Kent's Cavern should not have been acquired by some public body to ensure its safe-keeping, will read with mixed feelings a sketch of the life and labours of the Rev. John MacEnery (1796–1841) by the Rev. Kevin Clark, of which instalments appear in the October and November issues of *Blackfriars*. MacEnery was private chaplain to the Carey family of Tor Abbey while carrying on his exploration of the cavern, and had no other financial resources. Consequently his valuable notes remained unpublished at the time of his death, and apparently disappeared when his collections were dispersed by auction. The manuscript describing his explorations was printed by the Devonshire Association in 1869; but his notes, which were to be worked up into the promised "Cavern Researches," but never appeared, would probably raise still further the reputation of the man whose opinions on the age of the stone implements found beneath the stalagmite have been vindicated by time as against those of his distinguished correspondents, Buckland and Cuvier.

IN the issue of NATURE of September 12, p. 396, Dr. A. Gaschler referred to experiments he had made, in which he had obtained by artificial means an increase of 1·4 to 20 times the normal yield of uranium X from the disintegration of uranium. In view of the significance of such a result, were it to be substantiated, the following remarks of O. Hahn and L. Meitner, which appeared in the issue of *Die Naturwissenschaften* for October 30, are of interest: "Dr. Gaschler has undertaken experiments at low potentials and with heavy currents in our laboratory and under our control. According to his previous communications he had, with this experimental arrangement, obtained a manifold increase in the activity of his uranium preparations. These experiments, according to our measurements, yielded absolutely negative results, and some failed in the preliminary stages. The experiments with high-tension currents were carried out elsewhere. The uranium preparation from such an experiment, undertaken in a

laboratory of the General Electric Company in Berlin, was handed over to us for examination by a gentleman interested in the phenomenon. Our measurements failed to reveal any detectable increase in the quantity of UX, although we should have been able readily to detect even an increase of only 1·4 times the normal amount. Owing to the importance of the problems involved, we feel it our duty to make this statement."

THE Report of the Meteorological Committee to the Air Council for the year ended March 31, 1925, has just been issued by H.M. Stationery Office (price 1*s.* 9*d.* net). This is the seventieth year of the Meteorological Office and the fifth year in which the cost of the Office has been borne on Air Ministry votes. A special feature of interest in the report is the establishment of a division to deal with questions concerning meteorology for airships, which has been rendered necessary by the decision of His Majesty's Government to proceed with the development of airships and ultimately to establish a regular airship service between Great Britain and India, and the formation of a permanent committee on agricultural meteorology in connexion with the Ministry of Agriculture. A general weather forecast covering all districts of the British Isles has been regularly sent to the British Broadcasting Company in place of the separate district forecasts previously supplied, and notifications when possible are issued of spells of settled weather. An important feature to improve weather forecasting during the year was the establishment by the Royal Air Force of a Meteorological Flight to obtain regular observations of upper air temperature by means of aeroplane flights. Gale warnings have proved very satisfactory. The study of atmospheric pollution has been continued, and an investigation into the effect of suspended impurity upon the incidence of bronchial diseases has been arranged in collaboration with the Ministry of Health. Marine meteorology continues to make good headway, and the many varied undertakings of the Meteorological Office show an increasing activity and general interest in the development of meteorology.

A BRIEF account of the visit of foreign men of science to Russia on the occasion of the celebration of the bicentenary of the Academy of Sciences, which appears in Bull. No. 14 of the U.S.S.R. Society of Cultural Relations with Foreign Countries, is supplemented by a survey of the various scientific and artistic activities which have been initiated or are being supported by the Soviets. Oriental studies have always formed an important part of the Academy's activities. Of these the most valuable was perhaps the "Buddhist Library" of 60 volumes, while the Tibetan collections were the richest in the world. These studies are now being continued by the publication of Pekarsky's Yakut dictionary, and important researches in Moslem culture are being carried on, the numismatic researches of Frein being specially noted. An expedition to investigate the condition of the workers in the Ural Mountains in the eighteenth and nineteenth centuries has already discovered a number of documents of importance for economic and social studies and collected headgear of the nineteenth century, implements used in punishing the workers, cut glass and pictures painted by serfs. A botanical expedition has left for Persia, and will study an unexplored region on the outskirts of Nishpur. Songs of various Caucasian peoples are being studied and edited with a special view to their relation to ancient eastern cultures. A large number of objects belonging to the thirteenth and fourteenth centuries has been found in the course of excavations of tombs, Moslem chapels, and other buildings in the Crimea by Prof. Borogdin. These discoveries throw much light on the culture of the ancient Tartars. An account of the excavations is to be published shortly.

THROUGH the interest of Prof. William Trelease, of Illinois, U.S.A., who had personal relations with three generations of the distinguished botanists commemorated, the City of Geneva has marked their one-time residence at 3 Cour de St. Pierre with a tablet bearing the following inscription: "Ici ont vécu et travaillé pendant un siècle les botanistes genevois Augustin-Pyramus de Candolle, 1778–1841; Alphonse de Candolle, 1806–1893; Casimir de Candolle, 1836–1918; Augustin de Candolle, 1868–1920."

IT is announced in *Science* that Dr. J. B. Whitehead, professor of electrical engineering and dean of the faculty of engineering of the Johns Hopkins University, Baltimore, has been awarded the triennial prize, for the year 1925, of the Fondation George Montefiore of Liège, Belgium, for the best original work contributing to scientific advancement in the technical applications of electricity. The prize is awarded for his series of papers entitled "Gaseous Ionisation in Built-up Insulation." The amount of the prize this year is 4000 francs. This is the second time that Dr. Whitehead has been awarded this prize.

THE Council of the Iron and Steel Institute makes annually a limited number of grants from the research fund founded by the late Mr. Andrew Carnegie in aid of metallurgical research work. The object of the scheme is to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches on problems of practical and scientific importance relating to the metallurgy of iron and steel and allied subjects. Candidates, who must be under thirty-five years of age, must apply before the end of next February on a special form to be obtained from the Secretary of the Institute, 28 Victoria Street, London, S.W.1. The value of the grant will not exceed 100*l.* in any one year.

WE learn from *Science* of October 30 that an expedition to Greenland is being organised by Prof. W. M. Hobbs. The main object of the expedition, which will leave the United States in July next year, will be the establishment of a meteorological observatory on the inland ice at an altitude of 6000 to 7000 feet some hundred and fifty miles from the west coast. A staff will be maintained there for a year, and the data will be transmitted daily by wireless to the United States and Europe. Prof. Hobbs believes that this service will be of great value in

forecasting. The expedition will co-operate with Dr. L. Koch, who is to lead a Danish scientific party to Scoresby Sound on the east coast, and to cross the interior to Holstenborg on the west coast. This journey is expected to occupy about two months. A further object of Prof. Hobbs's inland station will be the investigation of the upper atmosphere by means of rubber balloons. It is also proposed to take two aeroplanes for reconnaissance work over the ice cap in various directions.

A BIBLIOGRAPHY of meteorological literature, No. 8, prepared by the Royal Meteorological Society with the collaboration of the Meteorological Office, has recently been issued by the Royal Meteorological Society (price 2*s*. 6*d*. to non-fellows). The bibliography was incorporated in the Meteorological Society's Journal from 1917 until 1920, but has since been issued as a separate publication in six-monthly parts. The publication is of considerable value to students of meteorology in all parts of the world.

THE British Museum (Natural History) has recently issued an illustrated brochure entitled "British Mosquitoes and their Control," which is obtainable at the Museum or through booksellers for the low price of 6*d*. This pamphlet forms No. 4 of the Economic Series and is written by Mr. F. W. Edwards and Col. S. P. James, who are recognised authorities on their subject. Practically all the information commonly sought for by medical officers and the general public will be found readily available in its pages. The distribution and habits of the twenty-six species of British mosquitoes are briefly, but clearly, described, and there is a useful account of remedial and control measures.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—Assistant at the Low Temperature Research Station, Cambridge—Secretary, Department of Scientific and Industrial Research, 16 Old Queen Street, S.W.1 (December 14). Chair of philosophy—Registrar, University, Bristol (February 1). Lectureships in botany and in domestic science—Secretary. Huguenot University College, Wellington, C.P., South Africa. Biochemist—British Association of Research for the Cocoa, Chocolate, Sugar, Confectionery and Jam Trades, 2 Dalmeny Avenue, N.7.

Our Astronomical Column.

THE NEW COMETS.—These have both been well observed. The orbit of Comet van Biesbroeck presented great difficulties owing to the apparent motion being slow and almost directly from the sun. The following orbit by J. Möller and B. Strömgren is the best available, but it is still very uncertain:

T 1925 Sept. 29·370 U.T.
ω 99° 10·73′ } 1925·0
Ω 334 46·45 }
i 46 57·15
$\log q$ 0·16043

EPHEMERIS FOR 0^h.

	R.A.	N. Decl.	log r.	log Δ.
Dec. 2.	12^h 5·5^m	30° 13′	0·2310	0·1842
10.	12 7·1	27 55	0·2460	0·1751
18.	12 6·3	25 48	0·2929	0·1647

The brightness is slowly declining.

The following orbit of Comet Wilk-Peltier is from rather rough observations, but is fairly near the truth.

T 1925 Dec. 6·936 U.T.
ω 117° 56′
Ω 131 47
i 144 59
$\log q$ 9·88422

EPHEMERIS FOR 0^h.

	R.A.	Decl.	log r.	log Δ.
Dec. 4.	19^h 19·6^m	4° 38′ N.	9·885	9·961
8.	19 33·4	0 2 S.	9·884	0·018
12.	19 43·4	3 47 S.	9·888	0·068
16.	19 51·0	6 53 S.	9·896	0·113

THE ORIGIN OF THE STARS.—A letter by Dr. J. H. Jeans in the *Observatory* (November) is of interest as tracing the modifications of his views that have taken place as new determinations have been made of the distances of the spiral nebulæ. In a paper in *Phil. Trans. Roy. Soc.* for 1902 he showed that condensations forming stars might be expected to appear in gaseous masses of density 10^{-23}, their distance apart being 10 parsecs. In 1917 he concluded that this process might be going on in the spiral nebulæ, the visible condensations being taken as the nuclei of stars. The distances were at first assumed from Van Maanen's measures, but the recent discovery of Cepheids in the spirals indicates a much greater distance for them, and the masses of the condensations are increased from 3 sun to 16 sun. The only revision of his earlier work that he finds necessary is to conjecture that the radiation of the nebula as a whole is governed by different laws from that of the stars formed from it. The new-born stars are not necessarily giants: if the density of the nebula is as high as 10^{-16}, they will be dwarfs. It is conjectured that the group of nebulæ near the galactic pole R.A. 12^h 37^m, N. Decl. 14°, may be of this character.

A MASSIVE SPECTROSCOPIC BINARY.—Orbits of many spectroscopic binaries are appearing regularly in the Publications of the Victoria Observatory. Vol. 3, No. 6 deals with an interesting star, No. 216014 in the Henry Draper Catalogue: its R.A. is 22^h 44·2^m, N. Decl. 64° 32′, magnitude 6·8: spectrum Bo. The period is 2·3 days, and the minimum masses are 14·23 and 12·37 in terms of the sun, the probable values being half as great again, placing the system among the six most massive ones. The absolute magnitude is given as −2·67, implying a distance of 3400 light-years. The radial velocity of the system is −23·10 km./sec. The H and K calcium lines are sharp, and give a constant radial velocity of −26·28 km./sec. The component of the solar velocity is only −11·40 km./sec., so that the calcium cloud is not stationary with respect to the stellar system, as in some cases. It is conjectured to belong to the binary system, but to be 40 or 50 astronomical units from the stars, at which distance it would not show an oscillation. The diameters of the stars are estimated as 5·4 times that of the sun, giving a density of 0·08 sun. The relative orbital velocity is nearly 500 km./sec.

Research Items.

THE INTERPRETATION OF PREHISTORIC "FINDS."—An interesting example of the light which can be thrown upon prehistoric objects of doubtful use by ethnographic data is given by Dr. Paul Rivet in the *Compte rendu* of the Liège meeting (1924) of the French Association for the Advancement of Science. Count Bégouen found in the cave at Montesquieu-Avantès (Ariège) an object of stone of which the surfaces were pitted with holes, most of them pierced right through from side to side. The date was either Magdalenian or Neolithic, it was uncertain which. A second object similar in certain respects—the figure of a feline—was found in a Magdalenian stratum in the grotto of Isturitz (Basse Pyrénees). It is, like the object previously described, pierced with holes, five in number, and in addition it is engraved. Four of the engravings appear to represent stylised barbed harpoons. Dr. Rivet suggests a common purpose for these dissimilar objects. He compares them with certain objects of ivory in use among modern Eskimo and described by Culin in his study of the games of American Indians. These are used for a species of cup and ball game, not, however, purely for amusement. Eskimo children use these objects when the sun first reappears after the long winter, to hasten his complete return. The game is definitely magical. In the same way the piercing of the hole by a point of bone in the prehistoric specimens may have been a magical ceremony symbolic of the piercing of game and practised before a hunting expedition.

PLACE-NAMES OF THE VIRGIN ISLANDS.—Since the acquisition in 1917 of the Danish Virgin Islands by the United States, the Coast and Geodetic Survey has been active in the preparation of a modern map and in amplifying the survey of the coastal waters. Although the earliest map of St. Croix was so old as 1671, there was no modern map of the islands incorporating accurate surveys. The latest effort of the Coast and Geodetic Survey is a Geographic Dictionary of the Virgin Islands of the United States by J. W. McGuire (Special Publication No. 103). In this gazetteer all place-names are entered with a note of their situation and derivation, and an indication of those which are rejected as being misspelt, superfluous or obsolete. From the length of the list of works consulted, it is clear that no trouble has been spared in compiling a trustworthy and scholarly guide to the place-names of these islands. The pamphlet also contains an introductory geographical chapter.

THE CYTOLOGY OF CANCER.—The September issue of the *Journal of the Royal Microscopical Society* opens with an admirable account of the general and experimental cytology of cancer by Dr. R. J. Ludford. In order to traverse the wide field more rapidly, Dr. Ludford has summarised the observations and theories in the form of twenty-one diagrams, either original or based on published figures. He gives a brief account of the behaviour of the nucleus and of the cytoplasmic organs—mitochondria, the Golgi apparatus, and the much discussed Plimmer's or bird's-eye bodies—and of keratinisation, and the formation of fat and pigment, and appends a summary of the properties of cancer cells cultivated *in vitro*. In his conclusion Dr. Ludford points out that with present microscopic technique there is no means of distinguishing between a normal and a cancerous cell. The virus of cancer, cultivated by Gye and photographed by Barnard, is smaller than the largest colloidal particles in the cell, and too small to be seen with the microscopes in common use.

THE CONTINUITY OF THE VERTEBRATE NERVOUS SYSTEM.—Frances M. Ballantyne (*Trans. R. Soc. Edin.*, vol. 53, pp. 663-670) records observations on the development of sensory nerves in Lepidosiren, and states that the olfactory nerve, the auditory nerve, and the spinal sensory nerves are at first protoplasmic bridges—each being a continuous strand and not a chain of discrete cells—which become fibrillated and lengthen as the embryo forms. Careful observation of large motor neurones in the spinal cord has convinced the author that the terminals of the axons, instead of ending in a club on the surface of the next neurone, really penetrate into its substance, and their neurofibrillæ pass directly and without a break through the cell and along its axon. No sign of a network either in or around the cell could be observed, and the neurofibrils are straight and unbranched within the cell. The dendrites of the neurone are at first thick processes which branch repeatedly and end in tapering threads of cytoplasm which appear to be without neurofibrillæ. The axon branches penetrate either into the body of the cell or into the thick proximal part of the dendrites, and the author supports the view that the great development of the dendrites, with their many branches, is to increase the surface of the cell in order to facilitate the metabolic processes, that is, the function of the dendrites is nutritive rather than nervous.

LEAF-MINING DIPTERA.—Memoir 78 (August 1924) of the Cornell University Agricultural Experiment Station deals with the leaf-mining Diptera of North America. Its author, Mr. S. W. Frost, brings together a good deal of useful information which will appeal to the dipterist and to the economic entomologist. The leaf-mining habit is regarded as having developed from the scavenger habit. Larvæ, having first entered the plant as scavengers, became adapted to an existence within the living host, and finally migrated to the stems and leaves, where they are now miners. It appears that 287 genera, including 589 species of North American plants, are affected by leaf-mining Diptera. The fly *Agromyza curvipalpis* var. *texana* Mall., for example, mines 15 species of Compositæ, and *Cerodontia femoralis* Meig. mines 22 species of Gramineæ. On the other hand, *Agromyza pusilla* Meig. has been recorded from 17 different families of plants, while at the opposite extreme there are other Diptera only known from a single species of plant host. Altogether there are 11 genera, including 61 species of Diptera, recorded as having the leaf-mining habit in North America, and they pertain to six families only. These families are the Cecidomyiidæ, Trypaneidæ, Agromyzidæ, Drosophilidæ, Ephydridæ, and Anthomyiidæ. Biological and descriptive accounts of these various species occupy pp. 29-132, and there follow lists of the leaf-mining Diptera of the world classified both under plant names and insect names. These two catalogues are useful compilations and appear remarkably complete. At the end of the memoir there is a very full bibliography of the subject.

SUGGESTED ALTERNATION OF GENERATIONS IN THE RED ALGÆ.—Prof. R. W. Phillips has certainly resuscitated from the literature a very interesting problem connected with the alternation of generations in the genera Phyllophora, Gymnogongrus, and Ahnfeldtia (*New Phytologist*, vol. 24, pp. 241-255, 1925). Whilst a few species seem to show normal alternation of sexual and tetrasporic generation, in others the tetrasporic generation has not been recorded. But

in these others curious warts have been recorded, which prove to be of the nature of nemathecia, that is, fructifications consisting of threads in which the successive cells of the threads become converted into tetraspores. Schmitz thoroughly investigated these more than thirty years ago and convinced himself and his fellow-investigators that these fructifications were of parasitic nature, and not the tetraspores of the host. In that case, where is the tetrasporic generation of the host plant? Prof. Phillips recalls the curious habit these marine algæ have of being parasitic on a nearly allied plant, and asks the pertinent question whether this is not a more striking example still of this with the parasite actually the tetrasporic generation of the same plant.

PRESERVATION OF PLANT TISSUES IN MUD.—Any hint as to the condition under which plant structures may be preserved in soil long enough to permit of their subsequent petrifaction may ultimately prove of value in the interpretation of fossil structure. It is well, therefore, to have placed on record such observations as those of R. E. Hunter and Winifred E. Mottram (*New Phytologist*, vol. 24, pp. 193-206, 1925), who noted that the moving shingle bank at Blakeney had left exposed some of the old marsh mud containing plant remains which, to judge from the rate of shingle movement, etc., were upwards of 200 years old. The authors have thus been led to undertake the troublesome task of trenching in the salt-pan of the marsh, after drainage. The results show that the roots of the living plants penetrate to considerable depths, and that, in certain circumstances, a plant such as Triglochin may decay at the base very slowly whilst the living crown continues active for a very long time. They concluded from the rate of accretion of the marsh that a plant of Triglochin examined was perhaps thirty-six years old. The plants exposed by movement of shingle were stems of *Statice Limonium*, and were *in situ*. Investigation of the actual marsh does not appear to have cleared up adequately their presence here, but it has shown that the conditions existing in certain types of "soft" salt-marsh pan certainly favour the preservation of plant remains.

BURMESE PERISSODACTYLA.—Dr. Pilgrim has published in a memoir of the Geological Survey of India (vol. 8, No. 3, 1925) an account of the Eocene Perissodactyla of Burma. These are represented by members of the Titanotheriidæ, of the Amynodontidæ, an aberrant family of rhinoceroses, and of the Tapiridæ. The discovery of titanotheres in Burma is of great interest. The family is typically American, and the only other parts of the world in which it has so far been found are Transylvania, with the sole genus Brachydiastematotherium, and the newly discovered forms obtained in Mongolia by the American Museum of Natural History expedition. Dr. Pilgrim describes a new genus, Sivatitanops, and also a form ascribed to the American genus Eotitanotherium. The memoir is well illustrated, but on the technical side the types used by the Publication Department of the Government of India need renewing and the type-setting a stricter supervision.

EARTHQUAKES IN NEW ZEALAND.—The report of the Dominion Observatory, New Zealand, 1924–25 (Bulletin No. 58), contains some notes on the earthquakes of 1924. The Milne seismograph was in operation throughout the year, and the Milne-Shaw seismograph from February 8. During the last ten months of the year, 62 earthquakes were recorded by the former, and 73 by the latter, instrument. Seventy earthquakes were felt during the year, sixty in the North Island and ten in the South Island, none of which attained a destructive intensity. Maps have been prepared and will shortly be published showing in considerable detail the distribution and intensity of the earthquakes felt in New Zealand.

OBSERVATION OF EARTHQUAKES IN A RAILWAY TUNNEL.—It is well known that earthquakes are either not felt at all or felt only slightly in railway tunnels and mines, even when the shocks at the surface are very strong. In the great Japanese earthquake of September 1, 1923, the damage to tunnels was very slight, and occurred only a few yards from either end. To determine the rate at which the amplitude decreases with increase of depth, Mr. S. Nakamura (*Proc. Phys.-Math. Soc. of Japan*, vol. 7, 1925, pp. 127–130) placed two of Omori's tromometers, one in a transverse shaft connecting two parallel tunnels each 1½ miles long at a depth of 375 feet below the surface and nearly 500 yards from the northern end, the other just outside the tunnel at that end. Comparisons were made for nine earthquakes during the first three months of the present year, and they show that, as a rule, the amplitude of the principal vibrations was less in the tunnel than outside, the ratio ranging from 0·19 to 1·93. Though the general variation in the ratios of the amplitudes with varying periods agrees approximately with that computed from the formula for the Rayleigh waves, the agreement is not close enough to allow the inference that the observed waves were the Rayleigh waves.

PRECIPITATION IN SCANDINAVIA.—A new rainfall map of Norway and Sweden, on a scale of 1 : 2,500,000, is published by H. W. son Ahlmann in *Meddelanden från Statens Meteorologisk-Hydrografiska Anstalt*, Band 3, No. 4, Stockholm. The Swedish part is taken from the map by A. Waltén which previously appeared in the same publication. The Norwegian part is based on the rainfall statistics of the Norwegian Meteorological Institute and the volume of water in the Norwegian rivers. The author has devised also a method of finding the relation between the amount of precipitation and the extent of glaciation in any region. Values of rainfall based on the flow of rivers are adjusted by the addition of certain coefficients of evaporation. The coefficient decreases with the amount of fall, since great falls are at high elevations when temperature is low and evaporation not active. The only region where data were insufficient was Finmark, where rainfall stations are few and there is little present glaciation and no measurement of the flow of rivers. The map shows in a striking way the great variations in rainfall in Norway and the rapid decrease in amount from the west to the east of the Scandinavian peninsula.

UPPER AIR IN SAMOA.—A tentative discussion of pilot balloon flights has been made for the twenty months, May 1923–December 1924, at Apia, Western Samoa, in latitude 13° 48′ S., longitude 171° 47′ W., by Mr. Andrew Thomson, Director of the Apia Observatory, to obtain the direction and velocity of the trade winds at various altitudes, the nature of the antitrades overlying them, and the variation of these great air movements with the season of the year. Further observations are in progress, but it is not believed that up to a height of 12 km. (7·5 miles) the figures now given will be materially altered. The coasts of South America lie 6200 miles to the eastward, and the continent of Australia 2500 miles to the west, and the expanse of the ocean is otherwise free from the influence of land except for numerous islands, the influence of which is said to be inconsiderable. Apia

lies slightly to the south of the centre of the South-east Trades. On the open ocean in the immediate vicinity of Samoa, winds from the quadrant south-east to north-east blow for 48 per cent. of the time during the months of December and January, and 85 per cent. during June to August. The velocities of the balloons for the two periods May to October (the dry season) and November to April (the wet season) are resolved for each 0·5 kilometre of altitude into north-south and east-west components. The north-south component is weak and approximately the same for wet and dry seasons. The east-west components show that the trade-wind movement of the air to the west decreases steadily with altitude and becomes zero at 3 km. (1·9 miles) in November to February and at 7·2 km. (4·5 miles) in May to August. The eastward motion of the Antitrades setting in at these levels continues to a height of 12 km. (7·5 miles).

DIELECTRIC CONSTANTS OF UNSATURATED COMPOUNDS.—In the *Journal of the American Chemical Society* for October 1925, C. P. Smyth and C. T. Zahn give the results of measurements of the dielectric constants of ethane, ethylene, acetylene and α-butylene carried out in order to investigate the structure of unsaturated bonds. Other experiments have indicated that a double bond in a hydrocarbon chain often gives rise to a moment in the molecule which can be determined from the dielectric constant of the substance. The moments of the ethane, ethylene, acetylene and acetylene molecules are zero, but α-butylene has a small moment. This evidence shows that the electrons of an unsaturated bond are symmetrically arranged, but have a stronger field of force than a saturated bond. If the unsaturated bond is not symmetrically placed in the molecule, the effect will be to give the substance a measurable moment.

DIMENSIONS OF MOLECULES.—By means of the Stephan-Maxwell-Jeans equation, calculations of the average cross-sectional areas for the molecules of substances can be made from their diffusion coefficients. The rate at which molecules diffuse through a gas depends not only on the absolute velocities of the molecules, but also on their size, since the possibility of collision increases with increasing size or cross-sectional area. In the *Journal of the American Chemical Society* for October 1925, E. Mack, Jr., describes a method of finding diffusion coefficients by direct weighing and gives values for several substances. The average cross-sectional areas of these were calculated from scale models in beeswax by shadow projection, and were in excellent agreement with the values found by the diffusion method, showing that the models of the molecules were of the correct shape. The experiments confirm the view that benzidene and diphenyl have a collapsed structure.

COMPUTATION OF SPECTRAL ENERGY.—The Department of Commerce of the Bureau of Standards has recently published a series of "Tables and Graphs for facilitating the Computation of Spectral Energy Distribution by Planck's Formula." The set consists of seven sheets each about 24 in. × 19 in., printed on stout paper, the price being the very reasonable one of 35 cents. Of the sheets, five are charts, the remaining two a sheet of explanations and a sheet of tables. Table 1, which will be of use to the general physicist, gives values of the intensity of radiation E_λ for different values of $\lambda\theta$ (λ = wave-length, θ = absolute temperature), expressed as fractions of the value at maximum, which occurs for $\lambda = \lambda_m$, where $\lambda_m\theta = 2890$. The values are given to four significant figures. Tables 2A and 2B give values of E_λ for λ from 0·4μ to 0·72μ, and for θ from 1000° to 28000°, the ordinates being on such a scale (different for each temperature) that $E_\lambda = 100$ at 0·59μ in Table 2A, at 0·56μ in Table 2B. The five charts provide graphs corresponding to the second of these tables, the scale being altered from chart to chart so as to provide an accuracy of 0·33 per cent. in the energy values, 0·1 per cent. in the temperatures. From such curves it is a very simple matter to deduce the colour-temperature of a radiator from observations of the relative energies at 0·56μ and one other wave-length. The graphs are on millimetre paper, and are very clearly executed. The value $C_2 = 14350$ is chosen for the radiation constant occurring in Planck's formula, though work done by Coblentz at the Bureau of Standards gave $C_2 = 14320$. It is shown, however, that this makes a negligible difference to the accuracy required, and in any case it is easy to use the charts in such a way as to allow for the difference.

METALLURGY IN ANCIENT MEXICO.—The method employed by the ancient Mexicans in the manufacture of certain metal objects has been repeatedly investigated with no very conclusive result. Strebel holds that although these objects have the appearance of wound wire welded or soldered together — and some were undoubtedly made by this process—the usual method employed was that of *la cire perdue*. They had not hitherto been submitted to microscopic examination. Dr. Axel Hultgren, however, has now applied this method of investigation to three exactly similar bronze bells from Nochistlan in Central Mexico, and has published the result in vol. 17, N.S. of the *Journ. des Américanistes de Paris*. Externally these bells have a grooved appearance suggesting that they have been made by winding a metal wire and subsequent welding, but internally they are perfectly smooth. An analysis of their composition gave copper 92·40, tin 6·95, lead 0·02, phosphorus 0·05, antimony less than 0·1, iron and aluminium less than 0·1. The microscopic examination showed the dendritic structure typical of cast alloys, and such as would be in accord with the chemical composition. The branches of the dendritic structure are the first formation of crystals in a falling temperature, and contain less tin than the material intervening between them which solidifies later. This proves, therefore, beyond question that the bells were cast. Had they been made from wire, the dendritic formation would have been distorted.

CONSTITUTION OF GLASS.—Prof. W. E. S. Turner has summarised the more important sections of our present knowledge of the nature and constitution of glass in a paper presented to the Society of Glass Technology and published in the Society's quarterly journal (September 1925). He has applied the Ramsay and Shields equation to the study of the molecular complexity of glasses with the aid of some data on surface tension and density, and has shown the fluid glass "molecules" to be of high molecular weight. Further investigation of the molecular complexity is developed by the application of indirect evidence. The existence of chemical compounds in glass has received attention, and the relation between percentage oxide content and the properties of thermal expansion, density, tensile strength, compression strength, etc., suggests that the oxides retain their individuality. The existence of breaks in the curves of composition—specific volume, etc., is taken as evidence of the presence of compounds. Much more investigation of physical and physico-chemical character is necessary before definite conclusions can be drawn. The same issue contains important communications from other authors on the constitution of glass.

Anniversary Meeting of the Royal Society.

IN his address on the occasion of the anniversary meeting of the Royal Society, held on November 30, the retiring president, Sir Charles Sherrington, referred to the heavy toll which death has taken of the Society since the last anniversary meeting. Brief mention was made of the lives and work of no less than twenty-three fellows and two foreign members who died during the past year. The president also spoke of the retirement of Sir William Hardy, biological secretary of the Society since 1915, on the completion of his statutory term of office.

The substance of the remainder of Sir Charles Sherrington's address is printed below.

The generous bequest of 10,000*l.* received last year from an anonymous donor for the promotion of medical research has this year, on the recommendation of the Tropical Diseases Committee of the Society, been resorted to for prosecuting investigation into the disease kala-azar, endemic in India and the Orient. At the instance of the Society, Major Patton and Dr. Hindle started for Northern China in June last in pursuance of that object. From the same generous and anonymous source a further munificent bequest has been received of something over 28,000*l.*, to be applied on the same terms and under the same condition of anonymity.

The Society, at the request of the Government, again organised, through a committee appointed for the purpose, an exhibition of pure science at the British Empire Exhibition. The catalogue of last year's exhibition was revised, enlarged and republished under the title "Phases of Modern Science." It is estimated that the Pure Science Exhibition was visited this year by at least 120,000 persons.

From the fund accruing to it in 1921 by the bequest of Miss Foulerton, the Society has this year been able, in pursuance of its scheme for advancing natural knowledge by the establishment of research professorships, to institute a further Foulerton Professorship, and the new Foulerton Professor appointed is Prof. A. Vivian Hill. Prof. Hill is already universally known as a most distinguished and fruitful investigator in animal physiology. He has placed the knowledge of muscular contraction upon a new footing. Taking up the problem from the viewpoint which chemical researches had at that time reached, Hill, by his own experiments, and experiments in conjunction with his pupils and others, has carried its study much further, especially in its physical aspects. The technique devised and the lines of analysis pursued have been masterly. He has attained preciser measurements, both of the energy changes and their time relations, and of the mechanical work realisable. Examining under various conditions the several ratios existing between these quantities, he has thrown fresh light upon the intimate mechanism of muscle. Not always has it been entirely welcome news that Prof. Hill has brought us about our muscles; we learn from him that they are sadly viscous machinery, but to that he reconciles us by pointing out compensatory advantages arising from that property. Deeper acquaintance with the principles underlying that function should enable better advantage to be taken of it. Some of Prof. Hill's results already touch practical issues. He is determining decisive factors concerned in the performance and maintenance of physical effort, and is tracing physiological characteristics underlying the skill and endurance of the athlete. Such researches promise information of value in regard to the management of muscular effort and its application on a wholesale scale to industrial labour. They also promise further insight into what may be termed manual skill. Prof. Hill's researches concern, therefore, questions of large practical as well as of theoretical importance.

As regards the biological papers brought before the Society during the past year, one feature which they display is that at this present time the growth of what one may term the experimental biological sciences—physiology, pathology, bacteriology, and pharmacology—is in some measure a convergent growth. Their individual boundaries seem more and more to merge. They are individual in their application rather than in their essential nature, and an advance made by one is of immediate advantage to all. Of any particular paper it would be often difficult, were it desirable, to say under which of these individual sciences it might best be singly classified or catalogued. Nor, under the elastic working of the Society, does that create difficulty; and that again affords evidence of the practical efficiency of our working arrangement.

With certain stages of growth there goes, on the other hand, increasing independence of an individual science. This seems so to-day for psychology viewed under the rubric of experimental biology. That psychology is rapidly growing is evident—not least so from its enhanced and successful application to practical problems lying before it in the sphere of industrial management and conditions of labour. Psychology as a part of experimental biology possesses, of course, recognised ties with the physiology and pathology of the nervous system; but on them it no longer explicitly leans to the extent it did. Its discipline becomes more intrinsically its own. This is, to my mind, well, and of favourable augury for its immediate progress as an experimental science. Concurrently with that tendency in psychology it is noteworthy that physiologists, Prof. Pavlov and his school, with, in Great Britain, Dr. Anrep, are pursuing analyses of complex behaviour of the higher animals under systematic avoidance of all reference, even by implication, to such psychical reactions as accompany that behaviour. Their method applies to animal behaviour in wider ambit than hitherto, the principles of reflex action. To illustrate by one example:—In his admirable Croonian lecture last June, Prof. Magnus described analyses by himself and his colleagues of the pure reflex behaviour of the cat without cerebral hemispheres. He showed how, for example, a moving mouse before the eyes of such a cat attitudinises the whole mechanism of the animal, exciting from it appropriate posture and direction in readiness for the final spring upon its prey. After that, "all the cat has to do is to decide to jump."

To jump or not to jump, that becomes the question. At such a point it is that the work of Pavlov and his school dovetails on to the work of Magnus and his school. Pavlov shows how in the intact animal such a final turning-point in its train of reactive behaviour—for example, "jump" or "not-jump"—can be studied as what is termed a "conditioned reflex"; he shows how that turning-point can be examined as the outcome of a balance between physiological impulsions and restraints, dependent partly on conditions under which the act is called for at the moment, partly on conditions under which it has been called for in the past—that is to say, the physiological history of the act in the individual, the mutual time-relations of the dominant stimuli, and so on. The result is thus treated as a sum of physiological factors, positive and negative, interacting under physiological rules, which can be determined, therefore, as obtaining for the

cerebral cortex. In this way is pursued a physiological study of higher nervous functions of the animal brain, without appeal to psychical reactions, of which, indeed, the method affirms nothing and denies nothing. To my thinking this line of attack is a gain both for physiology and for psychology, since psychology and physiology thus tread an essentially common terrain, yet do so each untrammelled by the other and without explicit reference to the eternal psycho-physical problem.

But it would be a far step, and a difficult, and of questionable gain, to carry such divorce of psychology and physiology into the study of fields such, for example, as human speech with what that connotes for reaction in the human brain. There it would seem better, as in Dr. Head's analysis of aphasia, to treat the anatomical, physiological and psychical data together. This seems the better, possibly the only, course of approach to those highest conjoint physiologico-psychological problems than which there can be few scientific problems which are of greater or more special interest to man.

PRESENTATION OF MEDALS.

THE COPLEY MEDAL: PROF. ALBERT EINSTEIN.

The name of Einstein is known to every one through the theory of relativity which he originated in 1905 and extended by a notable generalisation in 1915. Einstein realised that the time and space with which we are so directly acquainted by experience can be no other than the fictitious *local* time and space of the moving system—the motion in this case being that of the earth; we have no means of determining, nor can physical science be concerned with, any absolute reckoning of space and time. After this Einstein was led to the identification of mass with energy—another result of far-reaching importance, which allows us to know the exact amount of the store of energy so tantalisingly hidden within the atom.

There was a feeling that this theory of relativity for uniform motion must be a particular case of something more general; but observational knowledge seemed to oppose a decisive negative to any extension. It was Einstein again who found the way to the generalisation by bringing gravitation into his scheme.

Einstein's general theory of relativity is remarkable alike for the brilliance of conception and the mastery of the mathematical implement required to develop it. The new law of gravitation must be reckoned the first fundamental advance in the subject since the time of Newton. It involves an interaction between gravitation and light, which had indeed been suspected by Newton and almost taken for granted by Laplace, though it dropped out of scientific speculation when the corpuscular theory of light gave way to the undulatory theory. The three crucial astronomical tests of Einstein's theory have all been verified—the motion of perihelion of Mercury, the deflexion of light, and the red-shift of the spectral lines. The last-named proved the most difficult to test, but there is now general agreement that it is present in the solar spectrum. More recently Einstein's theory of gravitation has appealed to astronomers not merely as something which they are asked to test, but as a direct aid to the advancement of astronomical research. Invoked to decide the truth of a suspicion of transcendently high density in the "white dwarf" stars, it has decided that in the companion of Sirius matter is compressed to the almost incredible density of a ton to the cubic inch.

The other direction in which modern physical theory has broken away altogether from the ideas of the nineteenth century is in the quantum theory. Probably no one would claim that he really understands the quantum theory. For such illumination as we do possess we are in great measure indebted to Prof. Einstein. In 1905, almost at the same time as he published his first work on relativity, he put forward the famous law of the photo-electric effect, according to which the energy of a single quantum is employed in separating an electron from an atom and endowing it with kinetic energy. This was, perhaps, the first recognition that the development of the new quantum mechanics was not to be tied to classical mechanics by pictures of quasi-mechanical oscillators or other intermediate conceptions, but was to proceed independently on radically different principles. Noteworthy contributions followed on the theory of ionisation of material, and on the problem of the specific heats of solids. In 1917 Einstein reached another fundamental result—namely, the general equation connecting absorption and emission coefficients of all kinds. This gives deep insight into the origin of Planck's law of radiation, besides providing new formulæ with the widest practical applications.

A ROYAL MEDAL: PROF. WILLIAM HENRY PERKIN.

The science of organic chemistry owes a debt to Prof. Perkin, as instanced in recent years by his monograph on cryptopine and protopine, a record of chemical research rarely equalled in experimental skill and precise reasoning. He has revealed the constitutions of the alkaloids harmine and harmaline; he is nearing the solution of the structures of strychnine and brucine, two alkaloids which have hitherto resisted all attempts to determine their structural formulæ. His work on berberine has left few questions unanswered concerning the constitution of this important substance. He has developed new methods of attack on the chemistry of these natural products, and has faced many problems in structural organic chemistry. He succeeded, during a period of twenty years at the University of Manchester, in building up there a notable school of chemical research. During the past twelve years, in the University of Oxford, he has again organised and developed a similar research school.

A ROYAL MEDAL: PROF. ALBERT CHARLES SEWARD.

Prof. Seward's work has been conspicuous on account of the way in which he has extended and reduced to order our knowledge of the palæobotany of Gondwanaland, especially in India, South and Central Africa, Antarctica and the Falkland Islands. The lower stages of the Gondwana system are characterised by evidences of a glacial climate; and in order more completely to understand the conditions of life that existed, Prof. Seward has visited Greenland and otherwise paid special attention to the effect of climate and light in explaining the rise and luxuriance of the Glossopteris flora in the Southern Hemisphere. In addition to its direct stratigraphical value to geologists, his work has added greatly to our knowledge of plant migration, and especially of the way in which the Glossopteris flora invaded the Northern Hemisphere previously occupied by the groups familiar to us by our Coal Measure plants.

THE DAVY MEDAL: SIR JAMES IRVINE.

The constitution of the simpler sugars (monosaccharoses) was based on a sure foundation by the classical researches of Emil Fischer. Taking up the

investigation where Fischer had left it, Sir James has carried the inquiry into the more complex field of the disaccharoses, and by means of new processes, which he has been able to evolve and apply, to assign definite chemical structures to many of these most important natural products. He has also studied the constitutions of the still more complex polysaccharoses, starch and inulin, incidentally gaining an insight into the manner in which the plant forms and utilises these fundamental reserve materials.

THE SYLVESTER MEDAL: PROF. A. N. WHITEHEAD.

Always primarily interested in the foundations of mathematics, it is in the logical analysis of these foundations that Prof. Whitehead's reputation has been won. The great work, "Principia Mathematica," written in collaboration with Bertrand Russell, contains the most systematic and the most profound analysis to which the foundations of the subject have yet been submitted.

From pure mathematics both Prof. Whitehead and his collaborator have turned independently to physics. In his more recent books Whitehead has endeavoured to apply the spirit of "Principia Mathematica," and in particular the principle which he calls "extensive abstraction," in the more complicated and more controversial field of physical existence. That a point, whether in the older physics or the modern physics of space-time, is a class, or a class of classes, of events, that an electron is a systematic correlation of the characters of all events throughout all Nature, are doctrines at which the unsophisticated may be tempted to scoff, but the tendency of modern scientific thought is to the conclusion that, if the world of physics is indeed ultimately capable of any rational interpretation, it must be interpreted in some such way.

THE HUGHES MEDAL: MR. F. E. SMITH.

Mr. Smith began work on the realisation of the fundamental units of electrical measurement in 1902; and such further experiments as have been made since have served only to confirm his results. Other important investigations by Mr. Smith have dealt with the measurement of terrestrial magnetism. The recording magnetometers which he designed have proved of great value, while more recently he constructed, at the suggestion of Sir Arthur Schuster, a horizontal force magnetometer of extreme accuracy. During the War his services to the nation were of great importance, and since the Armistice, as Director of Research at the Admiralty, he has been responsible for a number of valuable investigations.

The Conference on Solid Smokeless Fuel in Sheffield.

A CONFERENCE on solid smokeless fuel was held in the Department of Applied Science at the University of Sheffield on Friday November 20. To point the moral, a tasty fog prevailed throughout the proceedings. The meeting was under the joint auspices of the Society of Chemical Industry, the Institution of Chemical Engineers, the Institution of Gas Engineers and the Midland Institute of Mining Engineers.

The objects of the meeting were to discuss methods of improving the quality of high-temperature coke and the alteration to present equipment and to plant which is required for the purpose. Dr. C. H. Lander contributed a general résumé, and papers were read by Dr. E. W. Smith on "The Qualities Requisite in a Solid Smokeless Fuel for Domestic Use," Prof. R. V. Wheeler on "The Production of Free-burning Solid Smokeless Fuel at High Temperatures," Mr. E. V. Evans on "The Combustibility and Reactivity of Coke," Mr. D. Rider on "Coke Quenching," and Mr. F. M. Birks on "Coke Handling, Screening and Breaking." There were about three hundred present, and the meeting was highly successful. In addition to the papers, investigations under the direction of Prof. Wheeler in the Fuel Department were inspected. There was also a demonstration of ordinary coke burning in open grates and in a closed one.

Low-temperature processes have been discussed with some thoroughness, and consequently the position as to these is fairly well known. Briefly, there is no low-temperature process. Many are the systems on paper, few are on works-sized concrete foundations, none show appreciable returns to the owners. It may be said of all, that none have mastered their engineering difficulties, few know even part of the chemistry of their products, whilst the efforts of all the systems have made no impression on the fuel question. It is clear that a low-temperature process will have to pass through the difficulties attending the evolution of the high-temperature process without any of the advantages attaching to these statutory bodies.

Such being the case, and assuming a demand for a free-burning solid smokeless fuel, can anything be done to render high-temperature coke more combustible and thus suitable for the domestic grate? If this can be done, then remembering that gas-works and coke-ovens together have an output of about 20 million tons of coke and that the domestic consumer consumes more than 40 million tons of coal per annum, the field for expansion is obvious. With regard to this scheme, it may be said that gas-works and coke-ovens do possess carbonisation technique, of a sort, capital has certainly been expended on them, they are old and tried servants.

If this were all, and provided high-temperature processes provide a free-burning fuel, then coke-ovens and gas-works have it. But it has yet to be proved that they can and will provide a coke that is easy to ignite, easy to keep alight, free from ash, low in moisture, clean and free from dust. But assuming that all this could be done and assuming that the combined output went to the domestic consumer —a very far-fetched assumption—only half of the domestic coal consumption would be displaced. A doubling of plant cannot reasonably be visualised within the next ten years.

Consequently there is still plenty of scope for low-temperature carbonisation, if the processes could be put on a commercial footing. Considerable interest was taken in low-temperature processes owing to the probable oil obtainable under these conditions. But a good deal more oil seems probable by the use of hydrogenation methods, the one process being yet as problematical as the other. Little is known of the composition of the liquid products of low-temperature processes. It is for this reason that low-temperature processes are desirable. It may well be that new classes of compounds may be brought to light with new properties and new uses. New drugs, new dyes, may be obtained, new substances with yet unknown benefit to mankind. Whatever the financial results from low temperature, the probable scientific results should be known.

The technical contributions to the subjects of the conference may be summed up in a short space, as was done by Prof. Wheeler. Fine grinding followed by blending, and the mixture of coals thus produced to be carbonised in narrow ovens under high-tempera-

ture conditions, the charge to be pushed when the centre of the coke reaches 700° C., seem likely to produce a more combustible coke. This opinion is based on some theory, on a fair amount of careful laboratory experiments, with but little large-scale confirmation, however.

Of scientific contributions there were naturally few; naturally, because of the newness, vastness and difficult character of the field. Concerning carbonisation, profound ignorance prevails. As to treatment and events beyond the hydraulic main there is still room for discussion—witness the recent contribution to this by Dr. Smith and Mr. Finlayson—but in respect to treatment and events, from the cold coal to the hydraulic main, there is no useful discussion. We do not know. There is much methane in coal gas; the methane has presumably been at 1000° C. or so. At this temperature methane deposits carbon and produces hydrogen. The shiny carbon—termed methane carbon—is accompanied by at least two, if not more than two, physically different forms of carbon. Moreover, from the deposit, it is almost as easy to pick out pieces of naphthalene as it is pieces of carbon.

At the Conference the terms reactivity and combustibility were used as synonyms. Korrevar has shown that they are as synonymous as silica and glass. Mr. E. V. Evans brought forward a new method for the determination of the combustibility of coke, as regards the utility in the open grate, and the method promises much. But as to reactivity, that intrinsic property of carbon, not much was said. The reactivity of carbon, which lies at the basis of the combustibility of that impure substance, coke, depends on the physical condition of the carbon, and at once we are back to the carbon deposits from methane cracking. If we know nothing concerning these deposits of carbon, what are we to say of our real knowledge of coke?

As Dr. H. M. Travers pointed out, at almost every stage of the carbonisation some very pertinent and unanswerable questions may be put. Why is primary tar formed at all—what is the mechanism of it? Why does coke at the later stages of carbonisation evolve hydrogen for the most part, and that in bursts with rise of temperature? He also put in a plea for research into fundamentals of fuel utilisation; if this be undertaken, then the Conference may well be a momentous one. He considers that the universities should undertake the work rather than, for example, the Fuel Research Board. His opinion is that progress is not likely to follow the permutations and combinations of well-known works processes. A difficulty is created, however, by the financial position of most of the universities of Great Britain. Many public-spirited industrialists know this, and there may be those, whether individuals or corporations, who would care to contribute towards the cost of research into fundamentals of this character.

Should means become available for the prosecution of the fundamental researches indicated, then a plea might be entered for the University of Sheffield, where there is a well-established school of fuel research. The list, distributed at the meeting, of work in progress, served to indicate the varied and extensive character of its activities. One could pass from Fuel Research Board apparatus, solvent resolution, to spontaneous combustion, momentary heating of coal, desulphurisation, combustion, coal constitution, synthetic ulmins, hydrogenation, flame work and microscopic work.

The Conference adjourned until February for a meeting at Manchester. S. L. B. ETHERTON.

The Early Nilotic, Libyan, and Egyptian Relations with Minoan Crete.

THE Huxley Memorial Lecture of the Royal Anthropological Institute for 1925 was delivered by Sir Arthur J. Evans at the rooms of the Royal Society on Tuesday, November 24. The chair was taken by Prof. C. G. Seligman, president of the Institute.

Sir Arthur Evans said Crete might be described as a half-way house between three continents, Europe, Asia, and Africa. Its fortunate situation marked it as the point where the primitive culture of our continent was first affected by the older civilisations of Egypt and the East. The most ancient geographical relations of Crete lay with Anatolia and the East. Man entered Crete from the Anatolian side; he may even have found the dwarf hippopotamus surviving from the times of the land-bridge of Miocene and Pleistocene times; but Palæolithic discoveries in Crete are still wanting and human remains from Neolithic times are still to seek. From Middle Minoan times a brachycephalic element is perceptible, mixed with the older dolichocephalic inhabitants, which may be due to an intrusion of "Armenoids" from Asia Minor, for which a portrait on a Middle Minoan seal supplies an argument. Archæological, religious, and linguistic evidence all point to a root connexion between Crete and Anatolia. The primitive female steatopygous figures from the Neolithic strata of Knossos find remarkable parallels from Asia Minor and so far afield as the Euphrates and Caspian. Stone maces and monochrome pottery show similar affinities. The pre-Hellenic language is related to old Carian and its kindred tongues.

It has been supposed that Egyptian relics found in connexion with Minoan and Mycenæan Crete arrived by the Syrian or Anatolian route, but this is unsupported by any evidence as regards the earlier contact of Crete with the Nile Valley. There is abundant proof that early man was not averse from deep-sea voyages. It is natural to suppose that in the East Mediterranean navigation began in the Ægean island world. Neither the Syrian nor the Libyan coast was favourable to its rise. Of Cretan vessels, the earliest representation is a clay model from Palaikastro of the First Early Minoan Period, which may be compared with the Nile craft such as those shown on the pottery of Naqada. There was a general use of sailing craft from an early date, and vessels with a single mast are of constant recurrence at the beginning of the Second Early Minoan Period in the first half of the third millennium B.C.

Evidence accumulating since 1890 of early relations between Crete and Egypt going back to the fourth Dynasty received remarkable confirmation from the beginning of the excavations at Knossos, in the form of imported Egyptian stone vessels of late prehistoric and protodynastic age and, more important, in derivative native Cretan forms in softer stone such as steatite and serpentine. In a Neolithic house of rectangular form found under the Central Court of the original Palace of Knossos, with fixed hearth of Anatolian type, was found among objects of pure Stone Age tradition a copper axe which must be regarded as an importation, not improbably from the Nile Valley. Two finds of special importance from this site were a gallipot-like vessel with clear traces of tubular drilling closely resembling a type of late predynastic and protodynastic Egyptian vessels, and two fragments of vessels of variegated stone which,

although like nothing found in Egypt or elsewhere, appear to be exotic and show that the Nilotic usage of stone vessels wrought in decorative materials had taken root at Knossos in the late Neolithic phase.

Among other elements of Cretan culture showing affinities to the early culture of the Nile and of the indigenous inhabitants of the opposite Libyan coasts, are the large stone ossuaries in the beehive form of the Messara plain on the southern border of the island, contrasting with the rectangular habitations of Crete. Stone idols from Hagia Triada curiously recall those found in predynastic Egypt. They show the high head and pointed beard of the Nilotic race, and possibly passed to Crete from Libya. The Cretan mode of head-dress and the type of loin clothing show either a resemblance or a general analogy with that of the Libyans. The Libyan Delta goddess appears to have been, in part at least, incorporated in the Cretan mother goddess, as is shown in the form of bow, arrows, and shield which are the attributes of the former. In the stone ossuaries, the discovery of palettes of stone similar to those used by the predynastic Egyptians for antimony and malachite to adorn the person are peculiarly significant.

These striking correspondences in forms and usage, and especially in the contracted burials of the vaulted tombs of Messara, the dolichocephalic skulls, and the recurrence of foot-shaped amulets of stone, suggest a settlement of a proto-Libyan element in the southern foreland of Crete. These tombs are of a true beehive type, but they differ from the Mycenæan examples in their entrance system. They represent a sepulchral type which has a wide diffusion in the old Libyan region of North Africa. This proto-Libyan settlement became entirely assimilated in the Old Cretan population, but the engrafting of this artistic element on the indigenous island stock may well have contributed to the later bloom of Minoan culture.

At the conclusion of the lecture, the president of the Institute presented the Huxley Medal to Sir Arthur Evans.

The Flame Spectra of Carbon Monoxide and Water Gas.

TWO papers by Mr. F. R. Weston, recently published in the *Proceedings of the Royal Society* (A, vol. 109, 1925, pp. 176-186 and 523-526), embody the results of researches into the flame spectra of carbon monoxide, hydrogen, water gas, etc., which he has conducted at the Imperial College of Science and Technology under the joint supervision of Profs. W. A. Bone and A. Fowler. The object of the researches was to elucidate certain aspects of the combustion of carbon monoxide, and notably whether or not this gas interacts *directly* with oxygen in flames, a point which has been much disputed amongst chemists during the past forty years, but now seems to be in the way of being definitely cleared up by the spectroscope.

The spectrum of a flame of undiluted carbon monoxide burning in air (or oxygen) at atmospheric pressure is shown to consist of a banded radiation, extending from 5000 Å.U. in the visible region to 2200 Å.U. far in the ultra-violet, upon which a continuous spectrum is superimposed. Both the banded and continuous parts of the spectrum, which are associated with the characteristic colour and actinic properties of a carbon monoxide flame, are most probably due to *direct* interactions between carbon monoxide and oxygen molecules in the flame, without any intervention of steam. At the same time, unless both the carbon monoxide and oxygen are previously dried before combustion, the spectrum shows some characteristic "steam lines," due to interactions between CO and OH_2 molecules in the flame, which proceed simultaneously with, and independently of, the CO and O_2 interactions.

As the carbon monoxide in the burning gas was progressively replaced by hydrogen, both the banded and continuous parts of the spectrum rapidly faded away, until with an equimolecular (that is, 50 CO + 50 H_2 by volume) mixture of the two combustible gases (water gas) only "steam lines" remained visible in the spectrum, the characteristic CO-radiation and flame-colour having almost entirely disappeared.

When a flame of undiluted carbon dioxide was burnt (undried) in oxygen under reduced pressure, the banded part of the spectrum became more distinct and the continuous part less intense as the pressure was diminished; the "steam lines" were invariably present in the spectrograms. When a flame of carbon monoxide, previously dried by passage through strong sulphuric acid, was burnt at atmospheric pressure in oxygen, similarly dried, the "steam lines" in the resulting spectra had almost disappeared (they were only faintly visible), whereas the intensity of the continuous part of the spectrum remained undiminished.

The conclusion drawn from the experiments is that in the flame of pure (undried) carbon monoxide two sets of independent interactions occur simultaneously, namely: (*a*) direct interactions between carbon monoxide and oxygen, exciting radiations which give rise to the continuous and banded parts of the spectrum, and to the characteristic blue colour of the flame, and (*b*) interactions between CO and OH_2 molecules, which originate the "steam lines" in the spectrum. When hydrogen is gradually added to the burning gas the relative proportions of the first-named interactions diminish rather rapidly and proportionately more of the carbon monoxide is burnt by interaction with OH_2-molecules, until when an equimolecular mixture of carbon monoxide and hydrogen is reached, the carbon monoxide-steam interactions occur to the practical exclusion of the carbon monoxide-oxygen interactions. These experiments have afforded the first clear evidence that in an ordinary carbon monoxide flame both sets of interactions are going on independently and simultaneously.

School Natural History Societies.

THE Marlborough College Natural History Society is interesting as a school institution which has had an unbroken existence since 1864, when it was founded under the auspices of the then headmaster, later Dean Bradley of Westminster; it now issues its seventy-third printed report. Marlborough is situated in an unique position for this study, with some primeval forest in Savernake on one side and the open savannahs of the Downs on the other. Between the two runs the Kennett, here quite a small sluggish stream noted for its excellent trout-fishing, with beds of willows and water meadows by its sides. Near its head waters, from six to seven miles away, lie Silbury Hill and Avebury, the latter with its immense stone circles. The Downs show dolmens and tumuli, most of the latter probably of much later age, and there

are numerous remains in camps, etc., of Roman times. The Report contains an account of excavations on the Wansdyke where it approaches Savernake Forest, and Mr. A. C. Brentall contributes a description of Martinsell, an old camp or cattle enclosure, three to four miles away, on the top of a chalk hill which falls precipitously to some of the richest agricultural ground of Wilts. Flint implements are common everywhere, as shown in an article by J. G. D. Clark, comparing 2000 specimens collected within two years at Marlborough and Seaford.

The permanent value of the whole series of reports lies, however, mainly in their descriptions of the natural history of one of the richest areas of the British Isles. The foundations of these were laid by such men as Preston and Hart-Smith in botany, Warde Fowler and Im Thurn (of British Guiana fame) in ornithology, and, above all, by Edward Meyrick in entomology, the latter not only a genius in his scientific work, but also in his task as a schoolmaster of developing the individuality of his pupils. Of the same type would appear to be Mr. A. G. Lowndes, who has written an illustrated article on that peculiar shrimp-like freshwater Cheirocephalus, a relic of the primary period; he also contributes notes on other freshwater forms that he and his class are studying, while there are references to vacation parties taken to the Isle of Purbeck and to the laboratory of the Marine Biological Association at Plymouth.

Of other work we might refer to meteorological observations carried on for sixty years, to the flowering dates of plants and to the dates of capture of insects, regular features of the report. In these a boy, A. G. P. Michelmore, seems to be prominent, and he, too, is largely responsible for revised lists of several groups of insects within a ten-mile radius of Marlborough; really the record of 663 species of that very difficult group, the Diptera or flies, is extraordinary for a school natural history society.

In this age of systematised school games—organised exercise would be a better term—we particularly welcome a report such as this, showing individuality, sacrifice and keenness in both masters and boys. Nothing gives a greater zest and interest to one's later life than the art of observation of all one's surroundings, both large and small, taught perhaps best in natural history. We are, indeed, happy to see that in this great school there must be opportunities for healthful and profitable recreation apart from the compulsion of "games."

University and Educational Intelligence.

CAMBRIDGE.—Mr. F. B. Smith has been reappointed reader in estate management for five years as from October 1.

The Raymond Horton Smith prize for 1924–25 has been divided between Dr. J. H. Burn, of Emmanuel College, whose thesis was written on the effects of denervation of a limb, and Dr. G. A. Harrison, of Gonville and Caius College, who dealt with insulin and diabetes mellitus.

The University Commissioners have published a list of amendments to their recently proposed statutes. The department of forestry is to be grouped with agriculture in a joint faculty. The Financial Board is to have power at its discretion to require that a departmental imprest account shall be administered by some one other than the head of the department. This might prove to be a valuable controlling factor in the case of any department the finances of which did not at any time appear to be administered in the best interests of the University. A special exception to the statute which requires professors to retire at the age of sixty-five years is to be made in the case of Sir Humphry Rolleston, Bart., who accepted office at a time when the commissioners had intimated that they proposed to institute a retiring age of seventy years.

The Special Board of Agriculture and Forestry has presented a report of progress for the year 1924–25. The considerable number of students who obtained Imperial and commercial appointments is of great interest. Accounts are appended detailing the expenditure on research of about 38,000*l.* from the Development Fund of the Ministry of Agriculture.

LIVERPOOL.—Some relatives and friends of the late Sir William A. Herdman have founded a memorial scholarship at the University. This is open to graduates of British universities who are prepared to carry on research in marine zoology at Liverpool and at any British marine biological station. The scholarship has a present value of about 50*l.* per annum. Applications should be made to the Registrar before the first day of the summer term.

WE learn from the Paris correspondent of the *Times* that degrees of doctor *honoris causa* have been conferred at the Sorbonne upon the following, among others: Sir Ernest Rutherford, Cambridge; Mr. Noguchi, Rockefeller Institute, New York; Prof. I. P. Pavlov, Leningrad; M. Charles de la Vallée Poussin, Louvain; and Prof. Ettore Païs, Rome.

THE Committee of Award of the Commonwealth Fund announces that it is now prepared to receive applications for the fellowships to be awarded in 1926. The fellowships will normally be tenable at an approved American university for two years and are open to persons of British birth domiciled in England, Scotland, Wales, and Ireland who are graduates of recognised universities and are unmarried and not more than thirty years of age. Women as well as men may apply. Provision amounting to approximately 600*l.* per annum will be made for the total expenditure involved during the tenure of a fellowship. Applications must be forwarded through the authorities of the university or college of which the candidate is or was a member. The form of application can be obtained from the Secretary to the Committee, Mr. R. H. Simpson, 50 Russell Square, London, W.C.1. Applications must reach the Secretary by February 20 next.

THE effect of continuation classes on mill personnel was discussed at a luncheon meeting of the Lancashire Section of the Textile Institute on October 9. Mr. John Crompton, of Messrs. Burgess, Ledward and Co., Ltd., read a paper on this subject, which is published in the October number of the Institute's journal. Mr. Crompton makes out a strong case for the general adoption of the system of continuation classes, concurrent with workshop practice, for which the "Fisher Act" provides. The data on which he bases his arguments are derived chiefly from the experience of his own and other firms in employing boys and girls attending the continuation classes held in the Worsley Technical School, Walkden. He explains in detail how he has met the difficulty arising from machines being vacated by one set of operatives and requiring to be tended by others. He points out that at Rugby, the only town in England where day continuation schools are compulsory for all employees under the age of sixteen years, there is no juvenile unemployment, 90 per cent. of the employers pay wages for school attendance, 75 per cent. of the young persons attend voluntarily evening school activities in addition to the compulsory day classes, and these classes are proving the best method of establishing contact and oversight of a considerable

proportion of the population after the school-leaving age. "The managers of several works declare that the day continuation school is the best form of welfare effort, and that the humanising influence of real education is the only true welfare work."

THE annual meeting of the Geographical Association will be held on January 7-9 at the London School of Economics, under the presidency of Mr. W. G. A. Ormsby Gore, who will take as the subject of his presidential address "The Economic Geography of the British Empire." The very full programme includes lectures by Prof. J. L. Myres, on "Wayside Geography," by Sir John Russell, on "Cotton and the Nile," by Sir Halford Mackinder, on "The Teaching of Geography," and by Prof. P. M. Roxby, on "The Concept of Natural Regions in the Teaching of Geography, with special illustrations from China." University teachers of geography will hold a discussion on the compatibility of the training of the geographer with the acquisition of a university degree in geography, to be opened by Mrs. Ormsby, on the first day of the meeting, while on the last day there will be the following four concurrent discussions, the opener's name in each case being given in brackets: The place of geography in a two period a week geography course (Mr. C. G. Beasley), detail in geography lessons (Mr. C. Daryll Forde), geography in relation to other school subjects (Major A. G. Church), and geography for the younger children in primary schools (Miss R. M. Fleming). The afternoon of January 9 will be given over to excursions; arrangements have been made for (1) a walk across Hampstead Heath and a visit to the geography rooms of the William Ellis and Henrietta Barnett Schools, (2) a visit to the Science Museum, South Kensington, and (3) beating the bounds of the City of London under the guidance of Mrs. Ormsby. A publishers' exhibition of books of maps has also been arranged.

FROM the International Federation of University Women we have received a copy of the report of the Council meeting held at Brussels in July last. The list of constituent national federations comprises 23 countries, those with the largest membership being the United States of America (22,000), Great Britain (2000), Canada (1500), Australia (600), Ireland (350), South Africa (326), France (290), Switzerland (260), and New Zealand (250). Germany is not included. An application for affiliation has been received from Ukrainian university women, some of whom are in the Soviet Republic of the Ukraine and some in Poland. The most valuable of all the Federation's efforts for promoting intercourse are, says the president (Dean Gildersleeve of Barnard College, Columbia University), plans for fellowships and club-houses. For fellowships a campaign has been started for a "Million Dollar Fund." Awards have recently been made to Dr. Ethel McLennan of Australia, who is undertaking research work at Rothamsted, and to Dr. Elsa Mahler of Switzerland, who is continuing at Rome, Florence, and Arezzo, her work on Megarian bowls. For 1927 the Australian Federation offers two fellowships of 500*l.* each, one to be awarded to a non-British member of the International Federation and the other to a British member (excluding residents in Australia or New Zealand). There are international club-houses at which special privileges are offered to all travelling members of the Federation from other countries at Baltimore, New York, Philadelphia, Washington, Brussels, Montreal, Paris, Lyons, and London. The biennial conference of the Federation will be held in 1926 at Amsterdam and will include discussions of academic research, application of research to social problems, adult education, etc.

Early Science at Oxford.

December 7, 1683. Glass is found to be electricall only in ye cold, not by ye fire.

Dr. Plot gave an account of severall sorts of seeds, roots, leaves &c. brought from ye East Indies, and presented to ye Royal Society by Captain Knox. It having been affirmed, that probably seawater may be sweetened by being distilled from salt of Tartar, it was ordered to be tried how far ye distillation of brine from salt of Tartar might go towards ye sweetening of ye brine. It was orderd to be tried, whether Iron-ore melted, and cast into an ingot, lying north, and south, will acquire a verticity? As also whether water will bubble, after that a fire has, for some considerable time, been made over it, in like manner as it does when it boils by reason of a fire under it.

A letter was read from Dr. Antony Nuck, Anatomy Reader at the Hague, to Mr. Benbrig; wherein he promises to communicate to the Society, what Curiosities fall under his observation.

1686. An observation of ye Reverend Mr. Peck, Minister of Mayfeild in Sussex, concerning a Gentleman who had been long in the East Indies, and about a mounth after that he took ship from thence, was taken with a fainting *feaver*, and various indisposition, had a vein opened; the *bloud* was sqeezed out, and did accumulate like drops of melted wax: this gave releif, but about 3 weeks or a month after, his distemper returned; he was bled again; and thus his distemper and his bleeding continueed for some years. In ye intervals he was well. He was cured by chewing Rhubarb.

December 8, 1685. Dr. Plot presented a piece of Ebony from St. Christopher's; it is yellow after ye saw, and blackish after ye plane, and is ye heaviest wood, we have yet seen.

There being some discourse concerning ye antiquity of weighing things in air and water, Dr. Bernard was pleased to informe ye Society, that that method is mention'd in ye Misna.

Dr. Plot also shew'd ye Society some little stones found by Mr. Lloyd on a bank by ye wayside south of Islip Church; they are ye same with those described by Dr. Lister, only these had no side indented.

The Circulation of ye blood appearing most evident to sense in some partes of ye *Lacerta Aquatica* viewed through a microscope (which we must in justice own to have receiv'd first from ye minutes of ye Dublin Society) the tryall of this experiment before this Society was recomended to Mr. Hoy.

December 9, 1684. A Paper was presented, by Mr. Desmastres, makeing mention of ye Triall of some Experiments found in Kunckel, vizt: That spirits of wine and syrup of violets make a green;

That Spirit of wine, and Milk, in equall parts, curdle; and

That a few drops of Water and Spirit of wine, heat perceptibly.

A sheet of paper was præsented ye Society, made of ye Asbestus-Stone by Mr. Lloyd, Register to the Chymicall courses of ye Laboratory of Oxford. The paper was made thus.

Mr. Lloyd received a parcell of this stone from the Isle of Anglesey, part of which he pounded (crude as it was) and carrying it to a paper-mill, had it mixt with water in their troughs for that purpose; then taken up, like their other matter for paper, it ran together. But ye lint being heavy, and quickly subsiding they were forc't to stirr it often, and be very quick in their operation. It was thought it might be made much finer and whiter, if it could be made stronger and tough, so as to be fit for any use.

Societies and Academies.

LONDON.

Geological Society, November 4.—N. E. **Odell**: Preliminary notes on the geology of the eastern parts of central Spitsbergen; with especial reference to the problem of the Hecla Hook formation. Approximately, the area amounts to 2000 square miles, but only a relatively small portion of this could be actually examined. It consists of a mountainous tract much of which is submerged under "highland ice" and glaciers, and is therefore lacking in direct rock-evidence. But through this ice-covering break many "nunatakkr," and, on the west of the region, a high range of mountains—the Chydenius Range—of which Mount Newton (5445 feet) is claimed to be the culminating point of Spitsbergen. The rocks encountered include representatives of the metamorphic basement complex, the Hecla Hook formation (which is intimately associated with that complex), the Carboniferous system, and intrusive acid and basic igneous facies. No evidence was found of rocks earlier in age than the Hecla Hook series, and an Archæan formation must be presumed absent. The greatest acid intrusions are those of the pink and grey granites in the Mount Newton and Mount Chernishev massif, both of the pre-Carboniferous (and presumably pre-Devonian) age. They would appear to have been intruded at the time of the Caledonian folding, and though towards its close, yet prior to the earliest Devonian sedimentation. Except in the south, on the Nordenskiöld Glacier, the Devonian strata are entirely absent, having been eroded from the interfolded Hecla Hook sediments and granites before the transgression of the Upper Carboniferous sea. The Carboniferous is confined to the coast of Hinlopen Strait, from Cape Fanshawe so far south as Bismarck Strait, while Triassic deposits were not seen north of the latter.—K. S. **Sandford**: The geology of North-East Land (Spitsbergen). North-East Land is separated by a narrow strait from the main island of Spitsbergen, and is about 8000 square miles in area. A great part of the coast and the whole of the interior are completely hidden by ice, which forms a dome rising to about 2400 feet. The northern area consists of Older Palæozoic rocks, granite, and gneiss; the last two being probably younger than the ancient sedimentary rocks. A pink granite penetrates them, and has been found extensively developed in the southern part of this "northern oldland." An important discovery in 1924 was the south-eastern corner of this pink granite, in the middle of the east coast, which previously had been known only as an unbroken and precipitous ice-front over 100 miles long. The southern area of the Island is delimited from the northern by an east-and-west fjord. This is an area of undisturbed Upper Carboniferous and Permo-Carboniferous clays and cherts, to a visible thickness of more than 1000 feet: the fauna belongs to the Russian Province. The history of the Island has been one of quiescence and immunity from folding, in an area of shallow seas. It has been affected by vertical movements, also by acid intrusions (Palæozoic) and by basic intrusions (Cretaceous).

Royal Anthropological Institute, November 10.—J. P. T. **Burchell**: The "shell-mound" industry of Denmark as represented at Lower Halstow, Kent. The stratified finds made during 1924 in the coastal sections between Swalecliffe and Reculver upon the north coast of Kent consisted of a medieval midden of the fifteenth century containing roughly worked flint instruments for the purpose of opening up the shells of the oyster, cockle, whelk, and winkle; a midden of the Roman period containing pottery fragments, in addition to a series of occupation sites of the Early Iron Age in which were found several types of the pottery of that period accompanied by a few flint implements and flakes. A flint implement of Early St. Acheul times was found in the underlying Pleistocene gravels. This is the first instance of an implement being found *in situ* in these particular gravel sections. Further excavations were carried on during the current year. The site in question is on the western side of a tongue of land running out northwards into the centre of the Upchurch Marshes. Here, resting upon the surface of the London Clay, is a factory site of the Shell Mound period. This site consists of a series of circular patches 3 feet to 4 feet wide and 3 inches to 4 inches deep. They are composed of blackened earth and calcined flints. The implements occur most freely in these patches. The characteristic implements of the industry are the adze and "shell mound" axe or tranchet, whilst flakes, cores, core scrapers, core dressings, chisel-ended flakes, blades, discs, borers, points and scrapers of the end, round, side and hollow types, are well represented. A round quartzite pebble with both faces countersunk and two opposing ends much bruised was also found.

Optical Society, November 12.—S. A. **Emerson**: Some recent improvements in modern ophthalmic lenses. The paper discusses the limitations inherent in the usual forms of fused bifocal lenses, and the methods now being adopted for overcoming these limitations. In the newer bifocals the glass used for the reading segment has the same relative dispersion as that of the major lens. The fused lens has thus no more chromatic aberration in the reading portion than has an ordinary single lens of the power of the reading portion made from either glass. In the fused bifocals as usually made there is very limited control of the centering of the reading portion. By using suitably shaped reading portions, this difficulty has been largely overcome. For medium and high-power lenses, a reduction in weight and an improvement in appearance, together with an increase in the field of view, have been obtained.—W. **Swaine**: Relation of visual acuity and accommodation to ametropia. Artificially produced results on the author's own eye are compared with his theoretical table showing how degrees of ametropia affect visual badness (*i.e.* inverse of acuity).—H. H. **Emsley**: Irregular astigmatism of the eye—effect of correcting lenses. Experiments to test the grating acuity of the eye in different meridians reveal the presence of irregular acuity, or irregular astigmatism as it is called.—E. F. **Fincham**: Some causes of apparent astigmatism of the eye, other than cylindrical errors of refraction. Measurements of visual acuity of a hypermetropic eye were made with a grating test. These showed that although the eye was able to make the necessary adjustment of the accommodation to correct the hypermetropic error for any meridian, the acuity varied considerably in different meridians. Variations of acuity in different meridians can be explained upon the assumption of the presence of "veins" of unequal refractive index in the media, or the striated character of the crystalline lens. Owing to the hexagonal packing of the foveal cones, the separation of their outer extremities (presumably the sense organs) is different in different meridians. The separation is least in the three meridians in which lie the centres of adjacent hexagons.

DUBLIN.

Royal Dublin Society, October 27.—L. B. **Smyth**: A contribution to the geology of Great Orme's Head. Great Orme's Head in North Wales consists of at least 1230 feet of Carboniferous limestone. The uppermost 180 feet are nearly barren, cherty limestones. They rest upon 50 feet of dark limestones and shales, the Bishop's Quarry beds, with a considerable fauna, including *Productus giganteus* (Mart.) in prodigious numbers, and *Posidonomya becheri* (Bronn.). Correlation is suggested with "Upper D_2" (Lamellibranch beds) of Garwood and Goodyear in the Craven district. The next 700 feet consist of pale to white limestones, graduating below to dark brown, with a few shales at the base. The latter have a fauna containing D_1 and D_2 forms. Below these shales all the limestone is dolomitised and no identifiable fossils were obtained. The thickness of the dolomite exposed is apparently 700 feet, but, owing to faults, may be only 300 feet. The base is hidden. One new species, *Clisiophyllum delicatum*, is described. Contemporaneous erosion is indicated at five horizons by the occurrence of local unconformities, limestone conglomerate, and current-bedded limestones and sandstones. The anomalous position of a mound of cherty limestone is probably due to transport by ice.

EDINBURGH.

Royal Society, November 9.—J. W. **Gregory**: (1) Scottish drumlins. Kames and drumlins are two of the most familiar features in Scottish scenery due to glacial deposits. Drumlins are elongated mounds of boulder clay which generally occur in parallel series and each has a steep broad bluff at one end, and tapers gently at the other. This form has been often attributed to the direct action of the ice by the deposition of the clay around a core of closely packed boulders. It is generally stated that drumlins are parallel to the direction of the ice movement. The Scottish drumlins have no such boulder core, and they are generally oblique to the ice movement, and are often at right angles to it. They are parallel to the prevalent wind direction as shown by the bending of the trees upon their crests. They are regarded as the characteristic form developed by boulder clay under the combined action of wind and rain. Some drumlins rest upon a core of rock which then determines their alignment; in these cases the effect of wind erosion is often shown by the development of secondary drumlins on the sides of the major drumlins. (2) Scottish kames. Kames are ridges of sand and gravel deposited during the melting of the ice sheets of the glacial period. They have been often identified with the Swedish osar and attributed to deposition in rivers flowing under or through glaciers. The distribution of the Scottish kames—excluding formations so-called which are moraines, drumlins, or banks left by the denudation of sheets of gravel—gives no support to this view, but shows that, like the ordinary Irish eskers, the American kames and similar formations in Finland, they were deposited as banks of gravel on the margin of an ice sheet melting in water. The chief Scottish kames occur at intervals along a line through eastern Scotland from Caithness to Berwickshire. They are all earlier than the 100-ft. raised beach except one at Dornoch. They are absent from the Highland Plateau, on which they would be expected to occur if due to sub-glacial rivers.—J. M. **Wordie**: Notes on the geology of Jan Mayen: The bulk of the island consists of lavas of basaltic composition, for the most part trachy-basalts; but among the early eruptions trachytes and condesite are found. In places there are great thicknesses of tuff, and sills of basic constitution are everywhere prominent. Beerenberg (8090 ft.) has never been active in historic times.—G. W. **Tyrrell**: The petrography of Jan Mayen. The Jan Mayen lavas consist of a mildly-alkalic series ranging from ankaramite (ultrabasic olivine-basalt), through trachy-basalts of various types, trachyandesites, to trachytes, of which seven new chemical analyses have been made. The suggested sequence of eruption is trachyte, trachy-basalt, and ankaramite, due to the downward freezing of a gravity-stratified magma.—Martin A. **Peacock**: The geology of Videy, S.W. Iceland; a record of igneous action in glacial times. The basement-rocks of Videy are a disturbed, downward succession of palagonite-tuff and breccia with included glacial blocks, "globular basalt" (akin to pillow-lava), and fine-grained, shattered basalt. Their structural and petrographic peculiarities may be explained by assuming that they were formed by "sub-glacial extrusion."

PARIS.

Academy of Sciences, October 19.—J. **Costantin**: An unsuspected case of plant pathology.— — **d'Arsonval**, F. **Bordas** and F. **Touplain**: The determination of the régime of mineral springs. A description of automatic instruments used for recording the temperature and output of the spring, and for taking a sample when a determined temperature is attained.— — **Riquier**: Some problems relating to the partial differential equation $\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}\right)^n u=0$.—A. **Calmette**, J. **Valtis**, L. **Nègre** and A. **Boquet**: Experimental infection through the placenta by the filtrable elements of the tubercular virus. Under certain experimental conditions the filtrable virulent elements arising from tuberculous products or from cultures of Koch bacilli, inoculated under the skin of guinea-pigs, can pass through the placenta, infect the fœtus and determine tuberculous lesions.—Paul **Mentré**: The simultaneous projective deformations of a congruence and of its two focal surfaces.—André **Roussel**: The method of adjunction of the calculus of variations.—Const. **Parvulesco**: The distribution of the stars in the globular clusters M.9, M.10, M.12, and the kinetic theory of gases.—Georges **Fournier**: The period of decay of radium E. The values found by the author, 4·86 days and 4·84 days, confirm the earlier results of Thaller (4·85 days), and are not in agreement with the recent figure of 4·98 days found by Bastings.—Jean Jacques **Trillat**: A method, using X-rays, by means of which the course of certain chemical reactions (the oxidation of unsaturated fatty acids) can be followed. A thin layer of the unsaturated acid was placed on a sheet of lead, and X-ray spectrographs taken at intervals. By this method the steps in the oxidation of oleic, linoleic and linolenic acids can be studied. The oxidation is brought about by successive additions of the same quantity of oxygen; and is accompanied by a molecular elongation of the order of 6 or 7 Å.U. This elongation renders the system unstable and is followed by polymerisation.—Fred **Vlès** and Mlle. Madeleine **Gex**: The behaviour of benzene in the presence of aqueous solutions: the ultra-violet absorption as a function of the *p*H. The experimental results are given as a curve, showing the ratio of the absorptions [λ260]/[λ254] as a function of the *p*H. The benzene molecule is not inert towards the hydrogen ions of the solution.—H. **Forestier** and G. **Chaudron**: The points of magnetic transformation in the system ferric oxide-magnesia. The study of the relation between temperature and

the magnetic properties of mixtures of ferric oxide and magnesia prove the existence of magnesium ferrite, $MgO.Fe_2O_3$. Ferrites of nickel, lime and cadmium, which are attracted by a magnet, have also been prepared.—A. **Boutaric** and Mlle. G. **Perreau**: The influence of some stable colloids on the flocculation of sols and of suspensions.—J. L. **Costa**: The mass spectra of some light elements. The values found are for hydrogen 1·0074 (positive ion) or 1·0079 (neutral atom); lithium 6·009 and 7·012.—Francis **Perrin**: The Brownian movement of rotation.—**Picon**: The action of a vacuum and of heat on the neutral and basic nitrates of bismuth. The estimation of the water of constitution and of nitric acid in these salts.—Const. A. **Ktenas**: The eruption of the volcano of Santorin. The morphological characters.—René **Souèges**: The embryogeny of the Crassulaceæ. Development of the embryo in *Sedum acre*.—Marc **Bridel**: The presence of two new ferments, primeverosidase and primeverase, in the emulsin of almonds.—G. **Rivière** and G. **Pichard**: The posterity of *Amygdalopersica Formonti*.—René **Hazard** and L. J. **Mercier**: The action of tropanol on the heart.—Armand **Dehorne**: Indications on the linome of some cellular categories.—M. and Mme. Georges **Teissier**: The embryonic growth of *Chrysaora hysocella*.— — **Samec**: The enzymatic hydrolysis of natural and synthetic amylophosphates.—Agasse **Lafont** and Roger **Douris**: The subcutaneous injection of gaseous substances such as oxygen.

SYDNEY.

Royal Society of New South Wales, September 2.—A. R. **Penfold**: The essential oil of *Eriostemon myoporoides*. This Rutaceous plant occurs along the coast to tableland districts of New South Wales, Victoria and Queensland, being very abundant at Emu Plains in the former State. The leaves and terminal branchlets yielded 0·75 per cent. of a very mobile yellow oil. Its principal constituents proved to be d-a-pinene (75-85 per cent.), ocimene, Ledum camphor, m.pt. 104° C., a sesquiterpene resembling aromandendrene, methyl anthranilate, a paraffin of m.pt. 64°-65° C., with traces of a phenolic body.—Sir George **Knibbs**: The human sex-ratio and the reduction of masculinity through large families. The live births in all western countries show an excess of males, and still births an even greater excess. Multiple births show greater femininity than ordinary. In Australia the proportion of females increases with the size of the family; thus in families of 1 to 3 there are 391 more boys than girls in 10,000 children; in families of 4 and 5 only 317 more; in families of 6, 7, 8, and 9 only about 246 more; in families of 10, 11, and 12 only 235 more. Taking the size of family given in "Who's Who," and using about half of the entries, the proportion is almost exactly what could have been predicted solely from the methods of probability, assuming equal chances for males and females. For example, in families of seven, the numbers for 7 boys, 6 boys and 1 girl, 5 boys and 2 girls, 4 boys and 3 girls, etc., were actually as on the top line

1	5	15	26	23	21	6	1
1	5	16	27	27	16	5	1.

The bottom line shows what might have been expected from probability. The masculinity, however, while it falls on the whole, is somewhat variable. There is a difference in the relative number of males in the living and deceased issue of families of from 1 to 9. The Australian results are based on 81,375 families and 454,372 children.—G. J. **Burrows** and A. E. **James**: Molecular solution volumes and association. A comparison of the solution volumes of several solutes in benzene, toluene, methyl alcohol and acetone suggests that the molecular solution volume is always greater in non-associated liquids such as benzene than in associated liquids such as methyl alcohol. When the solute is not associated the difference is small, but in the case of an associated solute there is a marked difference between its volume in benzene or toluene and that in alcohols or acetone. The molecular solution volume of a non-associated solute in any of these liquids does not differ very much from the molecular volume of the solute in the liquid condition, whereas an appreciable difference is observed in the case of an associated solute dissolved in an associated solvent.

WASHINGTON, D.C.

National Academy of Sciences (Proc. Vol. 11, No. 10, October).—Francis G. **Benedict** and Elizabeth E. **Crofts**: The fixity of basal metabolism. For a normal subject, half an hour's repose is sufficient to establish a condition giving trustworthy measurements of basal metabolism on any individual day. Even when exposure has reduced the skin temperature considerably, oxygen consumption measurements indicate that heat production is unchanged and thus independent of heat loss.—Tracy Yerkes **Thomas**: (1) Announcement of a projective theory of affinely connected manifolds. (2) On the equi-projective geometry of paths. Most of the theorems have their counterpart in the affine geometry of paths.—H. P. **Robertson**: Transformations of Einstein spaces.—Otto **Oldenberg**: On fluorescence radiation of nitrogen. A condensed spark arrangement is included inside a bulb containing the gas at very low pressure, and a ray from the spark excites faint fluorescence along its path. The fluorescence has a pure band spectrum containing bands due to the fluorescing ion and the fluorescing molecule.—A. H. **Compton** and R. L. **Doan**: X-ray spectra from a ruled diffraction grating. The grating was ruled on speculum with comparatively large grating spaces ($D = 2{\cdot}000 \times 10^{-3}$ cm.), and light ruling and very small glancing angles were used. Wave-lengths measured thus agree well with those obtained by reflection from a crystal.—Ralph D. **Bennett**: An attempt to test the quantum theory of X-ray scattering. Simultaneous registration of a recoil electron and a scattered X-ray quantum, at the angles predicted by Compton's theory, would be favourable evidence. Using Geiger point discharge counters and a solid, or hydrogen or air as a scattering target, co-incident effects were obtained, but they occurred in groups.—P. W. **Bridgman**: (1) The viscosity of liquids under pressure. For water, at low temperatures viscosity decreases with rising pressure to a minimum and then increases. This minimum disappears above about 25° C. All other liquids examined show uniform increase of viscosity with pressure, at first linearly but above 1000 kgm./sq. cm., the rate of increase grows rapidly, and generally the logarithmic curve becomes nearly straight. The temperature coefficient of viscosity also increases with pressure. (2) Thermal conductivity and thermo-electromotive force of single metal crystals. Thermal conductivity and thermo-electromotive force for bismuth, zinc, cadmium, and tin crystals for the range room-temperature to 100° C. were measured as a function of direction in the crystal. The results lead to the conclusion that there is a reversible absorption of heat within the crystal on changing the direction of the current (internal Peltier heat effect).—H B. **Wahlin**: The aging effect in the mobility of positive ions.—J. H. **Van Vleck**: On the quantum theory of the polarisation of resonance radiation in magnetic fields.—H. C. **Urey**: The structure of the hydrogen molecule ion.

The energy is calculated of the steady state of lowest energy of the hydrogen molecule ion, when the electron vibrates in a straight line perpendicular to, and through the mid point of, the line joining the nuclei.—Albert L. **Raymond**: The mechanism of carbohydrate utilisation. The steps in alcoholic fermentation are, briefly, hexose monophosphate ester, cleavage into two triose groups, one containing all the phosphorus, the latter becoming hexose diphosphate and the former yielding alcohol and carbon dioxide; and the hydrolysis of the diphosphate back to hexose. Carbohydrate metabolism in the animal is believed to be similar.—William D. **Harkins**: The separation of chlorine into isotopes (isotopic elements) and the whole-number rule for atomic weights. By diffusion through the walls of clay pipe-stems, hydrogen chloride was obtained containing chlorine of atomic weight $35{\cdot}417_7$ as compared with $35{\cdot}457_4$ for ordinary chlorine. It is hoped to investigate with this light fraction the spectral shift due to isotopes as found for ordinary lead and the lead produced by disintegration of uranium.—William D. **Harkins** and W. G. **Guy**: The radio-activity of potassium, rubidium, and other elements. The natural leak of a large ionisation chamber is balanced against that of a small chamber containing uranium oxide covered with aluminium foil to exclude α-radiation. The salts examined were placed in the large chamber, and the activities of rubidium and potassium found are as 1·39 : 1·00. It is concluded that the disintegration of an isotope is the source of the radiation from potassium.—William D. **Harkins** and Norvil **Beeman**: The oriented wedge theory of emulsions. If the oil-like or non-polar end of the soap molecule is smaller than the polar end, the emulsion will be one of oil in water; if the reverse be the case, the droplets will be of water. The size of the greatest number of drops is so much greater than the size of the sodium oleate molecule that it cannot be expected that the molecule should determine the size of the drop. Emulsifying agents, the molecules of which have larger non-polar or polar ends, are required to test the theory.—Williams D. **Harkins** and J. W. **Morgan**: Polymolecular and monomolecular films. Young's modulus for steel being about 12,000, that of a monomolecular film such as stearic acid on water is 39; a polymolecular film is generally much weaker. Films of mixed substances each giving a monomolecular film are also monomolecular.—William D. **Harkins** and S. B. **Stone**: The isotopic composition of the element chlorine in the meteorites: the atomic weight of meteoric and terrestrial chlorine (see NATURE, September 19, p. 426).—George L. **Clark**, P. C. **McGrath**, and M. C. **Johnson**: The effect of X-rays on the platinum catalyst in the contact sulphuric acid reaction. X-rays do not improve the yield if dry air is used. With moist air, an enormously greater conversion is obtained which is further increased, but only temporarily, by radiation of the catalyst.—Wm. H. **Gates**: The Japanese waltzing mouse, its origin and genetics. Both the waltzing and non-waltzing form of the Japanese mouse are derivatives of *Mus wagneri*, a native of Central Asia, and not of the common house mouse. In a cross with the latter, the characters of the waltzer tended to remain together in the F_2 generation.—A. J. H. **Russell**: A statistical approach to the epidemiology of cholera in Madras Presidency. The monthly mortality figures for the period 1902–21 are used, and the population dealt with numbers 43 millions. There is an annual and a six-yearly periodicity and a varying relationship in different areas with rainfall.—Harold **Hotelling**: The distribution of correlation ratios calculated from random data.—E. W. **Stearn**, B. F. **Sturdivant**, and A. E. **Stearn**: The life-history of a micro-parasite isolated from carcinomatous growths. Cultures or extracts of carcinomatous tissue give an organism the life-history of which seems to include rods, thread-like forms with tapering ends, cocci of various sizes, and large sporing bodies. The optimum temperature is 37°-41° C. In fluid from the tissue it is almost invisible and passes filters, but can be detected as a loosely coiled spirillum. In cultured colonies, under certain conditions, orthorhombic crystals appeared.

Official Publications Received.

Sin-sai Yobô Tyôsakwai Hôkoku. (Reports of the Imperial Earthquake Investigation Committee.) No. 100, A. Pp. vi+354+60 plates+3 maps. No. 100, B. Pp. iv+126+44 plates+3 maps. No. 100, E. Pp. vii+297+31 plates+13 maps. (Tokyo.)

Department of Commerce: Bureau of Standards. Miscellaneous Publications, Bureau of Standards, No. 64: History of the Standard Weights and Measures of the United States. By Louis A. Fischer. Pp. v+34. (Washington: Government Printing Office.) 15 cents.

United States Department of Agriculture: Department Bulletin No. 1319: The Brood-Rearing Cycle of the Honeybee. By W. J. Nolan. Pp. 56. (Washington: Government Printing Office.) 10 cents.

Report of the Aeronautical Research Institute, Tôkyô Imperial University. Vol. 1, No. 12: The Standard Atmosphere and the Corrections to be Applied to a Reading of an Altimeter. By Takuro Tamaru. Pp. 321-346. (Tokyo: Maruzen Kabushiki-Kaisha.) 50 yen.

Congrès International des Américanistes. Compte rendu de la XXIe session, Deuxième partie, tenue à Göteborg en 1924. Pp. xxxix+706. (Göteborg: Museum.)

United States Department of Agriculture. Department Bulletin No. 1359: Food of American Phalaropes, Avocets and Stilts. By Alexander Wetmore. Pp. 20+3 plates. (Washington: Government Printing Office.)

The Development of India's Forest Resources. Compiled by the Economic Branch of the Forest Research Institute, Dehra Dun. Pp. v+39+22 plates. (Calcutta: Government of India Central Publication Branch.) 2.12 rupees; 5s.

The National Institute of Agricultural Botany. Sixth Report and Accounts, 1924-25. Pp. 19. (Cambridge.)

Department of the Interior: Bureau of Education. Bulletin, 1925, No. 11: Accredited Secondary Schools in the United States. Pp. v+119. (Washington: Government Printing Office.) 15 cents.

Studies from the Connaught Laboratories, University of Toronto. Vol. 2, 1922-1925. Pp. 273. (Toronto: University of Toronto Press.)

The Linnean Society of New South Wales. Historical Notes of its First Fifty Years (Jubilee Publication). Compiled by Dr. A. B. Walkom. Pp. 46. (Sydney, N.S.W.)

Seale-Hayne Agricultural College, Newton Abbot, Devon. Pamphlet 17: The Cost of Food in Milk Production (Third Report). By D. R. Edwardes-Ker and T. J. Shaw. Pp. 21. (Newton Abbot, Devon.)

British Photographic Research Association. Report for the Year 1924-25. Pp. 10. (London.)

Aeronautical Research Committee. Reports and Memoranda, No. 967 (Ae. 183): An Experimental Study of the Vibrations in the Blades and Shaft of an Airscrew. By A. Fage. (A.3.d. Airscrews, 73—T. 1947.) Pp. 16+1 plate. (London: H.M. Stationery Office.) 9d. net.

British Cast Iron Research Association. Fourth Annual Report for the Year ending June 30th, 1925. Pp. 20. (Birmingham.)

Ministry of Agriculture and Fisheries. Miscellaneous Publications, No. 49: Report on the Occurrence of Insect Pests on Crops in England and Wales for the Years 1922, 1923 and 1924. Pp. 36. (London: Ministry of Agriculture and Fisheries.) 1s. 6d. net.

Ministry of Public Works, Egypt: Physical Department. Helwan Observatory, Bulletin No. 32: Corrections to Observed Times of Wireless Signals, 1922 November to 1924 June. By H. Knox-Shaw and P. A. Curry. Pp. 131-141. (Cairo: Government Publications Office.)

Spisy vydávané Přírodovědeckou Fakultou Masarykovy University (Publications de la Faculté des Sciences de l'Université Masaryk). Rédigées par Bohuslav Hostinský. Čís. 52: Iter Turcico-Persicum. Pars 2: Plantarum collectarum enumeratio (Compositæ). Scripsit Dr. Fr. Nábělek. Pp. 57+12 tab. Čís. 55: Nástin zeměpisného rozšíření lišejníků na Moravě vzhledem k poměrům evropským: srovnávací studie fytogeografická. (A Sketch of the Distribution of Lichens in Moravia with regard to the Conditions in Europe: a Phytogeographical Comparative Study.) Napsal Jindřich Suza. Pp. 152. Čís. 56: Onobrychis generis revisio critica. Pars prima. Scripsit G. Širjaev. Pp. 197+17 tab. Čís. 57: Studie o larvách Corixid I. (Études sur les larves des Corixides I.) Napsal V. Teyrovský. Pp. 13. Čís. 58: Parasitismus a metamorfosa druhu Gordius tolesanus Duj. (Parasitism and Metamorphosis of the species Gordius tolosanus Duj.) Napsal Jan Švábenik. Pp. 48+2 tab. Čís. 59: O růstových útvarech vznikajících reakcemi na rozhraní mezi roztoky elektrolytů ve vodě a v gelu. (On the Growth of Structures formed by Reactions on the Boundary between Solutions of Electrolytes in Water and those in Gel.) Napsal Vladimír Morávek. Pp. 42+5 tab. Čís. 60: Příspěvek ke kvantitativnímu stanovení kyseliny mléčné: mikromethoda ke stanovení v krvi. (Recherches sur le dosage de l'acide lactique: le microdosage dans le sang.) Napsali J. Frejka a K. Všetečka. Pp. 27. Čís. 61: Nový zjev elektrokinetický: Příspěvek ke studiu elektrokapilarity roztaveného kysličníku telluričitého. (Un nouveau phénomène électrocinétique: étude de l'électrocapillarité de l'oxide tellureux fondu.) Napsali A. Šimek a H. Kadlcová. Pp. 21+2 tab. Čís. 62: Rhamphorhynchus Gemmingi, H. v. Meyer. Napsal Fr. Řikovský. Pp. 14. Čís. 63: O absorpci plynného chlorovodíku v kyselině sírové. (The Absorption of Gaseous Hydrogen Chloride by Sulphuric Acid.) Napsal Václav Čupr. Pp. 18. (Brno.)

Diary of Societies.

MONDAY, DECEMBER 7.

ROYAL SOCIETY OF EDINBURGH, at 4.30.—W. J. M. Menzies: Salmon (*Salmo salar*) of the River Moisie, Eastern Canada.—Fred. J. Symon: The Diffusion of Salt Vapours in a Bunsen Flame.—William Cooper: Note on Copper-tinted Flame Caps.—F. A. E. Crew: Prenatal Death in the Pig, and its Effect upon the Sex-Ratio.—E. L. Ince: Researches into the Characteristic Numbers of the Mathieu Equation.—T. M. MacRobert: The Addition Theorem for the Legendre Functions of the Second Kind.—Sir Thomas Muir: The Theory of Continuants from 1900 to 1920.

VICTORIA INSTITUTE (at Central Buildings, Westminster), at 4.30.—G. B. Michell: Scientific Criticism of the Bible.

BIOCHEMICAL SOCIETY (in the Biochemical Laboratory, Imperial College of Science and Technology), at 5.—H. W. Buston and S. B. Schryver: The Isolation of some Further Undescribed Products of the Hydrolysis of Proteins.—H. Martin and S. B. Schryver: The Action of an Electric Field on Egg Albumin.—H. Chick: Sources of Error in the Biological Method of Investigating Fat-soluble Vitamins.—W. V. Thorpe: The Action of Enzymes on the Oxytocic Principle of the Pituitary.—R. K. Cannan: Potentiometric Studies in Biological Oxidation-Reductions.—D. T. Harris: The Action of Light on Blood.

SOCIETY OF ENGINEERS (at the Geological Society), at 5.30.—H. E. I. Taylor: The Growth of the Gothic Church Window.

BRITISH PSYCHOLOGICAL SOCIETY (Education Section) (Annual General Meeting) (at London Day Training College), at 6.—Prof. T. P. Nunn: Some Notes of a Visit to American Educational Institutions.

INSTITUTION OF STRUCTURAL ENGINEERS (Students' Meeting) (at Abbey House, 2 Victoria Street), at 6.—E. F. Etchells and others: Discussion on How to pass Examinations.

ROYAL INSTITUTION, at 7.—General Meeting.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—C. L. Lipman and others: Discussion on Design and Performance of Protective Relays.

INSTITUTION OF AUTOMOBILE ENGINEERS (Loughborough Graduates' Meeting) (at the College, Loughborough), at 7.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (Middlesbrough Graduate Section) (at Middlesbrough), at 7.30.—W. Goldsbrough: Testing of Turbo-Blowers.

OPTICAL SOCIETY (at Imperial College of Science), at 7.30.

INSTITUTION OF STRUCTURAL ENGINEERS (Midland Counties Branch) (at Birmingham), at 7.30.

ARISTOTELIAN SOCIETY (at University of London Club), at 8.—C. R. Morris: Judgment as the Fundamental Act of Knowledge.

ROYAL SOCIETY OF ARTS, at 8.—Dr. R. Lessing: Coal Ash and Clean Coal (Cantor Lectures, III.).

SURVEYORS' INSTITUTION, at 8.—Col. C. H. Bressey: Modern Methods of Roadmaking.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.—Prof. L. W. Collet: The Lakes of Scotland and of Switzerland.

BIOCHEMICAL SOCIETY (at Imperial College of Science).

SOCIETY OF CHEMICAL INDUSTRY (London Section) (Joint Meeting with the Institute of Chemistry, London and South-Eastern Counties Section) (at Institution of Mechanical Engineers), at 8.—W. J. U. Woolcock: Five Years of Progress in the Fine Chemical Industry.

TUESDAY, DECEMBER 8.

MANCHESTER GEOLOGICAL AND MINING SOCIETY, at 4.

INSTITUTION OF PETROLEUM TECHNOLOGISTS (at Royal Society of Arts), at 5.30.—J. H. S. Dickenson, B. Gray, and F. E. Cherry: The Selection and Properties of Steels used for Oil Well Boring Equipment.

INSTITUTE OF MARINE ENGINEERS, at 6.30.—M. L'Herminier: Powdered Fuel Developments.

INSTITUTION OF ELECTRICAL ENGINEERS (East Midland Sub-Centre) (at the College, Loughborough), at 6.45.—F. J. Moffatt: Address.

INSTITUTION OF ELECTRICAL ENGINEERS (North Midland Centre) (at Hotel Metropole, Leeds), at 7.—Prof. S. P. Smith: An All-Electric House.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—T. Thorne Baker and F. L. Davidson: A New Physical Method for the Examination of Gelatine.—E. L. Turner and C. D. Hallam: The Basis of the Image in Photo-Lithography.—F. J. Tritton: On the Theory of the Carbro Process.

INSTITUTION OF ELECTRICAL ENGINEERS (Scottish Centre) (at Royal Technical College, Glasgow), at 7.30.—Major E. I. David: Electricity in Mines.

INSTITUTION OF AUTOMOBILE ENGINEERS (Coventry Centre) (at Broadgate Café, Coventry), at 7.30.—General Meeting.

PHARMACEUTICAL SOCIETY, at 8.—Dr. A. W. Crossley: Cotton (Lantern Lecture).

ROYAL ANTHROPOLOGICAL INSTITUTE (Indian Section), at 8.15.—Capt. A. M. Hocart: The Buddha's Illumination.

INSTITUTION OF MECHANICAL ENGINEERS (Swansea Branch) (at Swansea).—

WEDNESDAY, DECEMBER 9.

ROYAL SOCIETY OF ARTS (Indian and Dominions and Colonies Sections), at 4.30.—Dr. H. M. Leake: The Imperial College of Tropical Agriculture.

RADIO SOCIETY OF GREAT BRITAIN (at the Institution of Electrical Engineers), at 6.—A. E. Bawtree: The Acoustics of the Headphone and Loud-Speaker.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (Graduate Section) (at Bolbec Hall, Newcastle-upon-Tyne), at 7.—T. B. Davison: Modern Transport.

INSTITUTION OF ENGINEERS-IN-CHARGE (at St. Bride's Institute, Bride Lane), at 7.30.—J. V. Stevens: Oil Fuel for Commercial Purposes.

INSTITUTION OF CHEMICAL ENGINEERS (at the Chemical Society, Burlington House).—Col. B. I. Rolling: Magnetic Separation.

INSTITUTION OF MECHANICAL ENGINEERS (Sheffield Branch) (at Sheffield).—H. F. L. Orcutt: Characteristics and Uses of Ground Gears.

THURSDAY, DECEMBER 10.

LONDON MATHEMATICAL SOCIETY, at 5.—H. Levy: The Analysis of an Empiric Function into its Quasi-Periodic Constituents.—J. C. Burkill: The Expressions in Stieltje's Integrals of the Inversion Formulæ of Fourier and Hankel.—W. L. Ferrar: (1) On the Summability (C, k) of Series of the Type $\Sigma a_n f_n$; (2) Necessary and Sufficient Conditions for Summability (C, r).—T. Stuart: (1) Fermat's Last Theorem: Arguments against a Solution; (2) The Diophantine Equation $X^4+Y^4+Z^4=AW^4$ where $A=1$ or 3.—G. H. Hardy and J. E. Littlewood: Two Theorems concerning Fourier Series.—T. Vijayaraghavan: A Tauberian Theorem.

CHILD-STUDY SOCIETY (at Royal Sanitary Institute), at 6.—Dr. R. Langdon-Down: The Teaching of Shorthand as Part of a General Education.

INSTITUTION OF STRUCTURAL ENGINEERS (Yorkshire Branch) (at Great Northern Hotel, Leeds), at 6.30.—E. F. Sargeant: Concrete Granary at Hull.

INSTITUTE OF METALS (London Local Section) (Joint Meeting with the Institution of British Foundrymen) (in the Rooms of the Institute of Marine Engineers), at 7.30.—J. B. Hoblyn: Commercial Aluminium Alloys from the Users' Point of View.

SOCIETY OF CHEMICAL INDUSTRY (Bristol Section) (at Bristol University), at 7.30.—S. H. Piper: The Use of X-rays in Chemistry.

INSTITUTE OF CHEMISTRY (Edinburgh and East of Scotland Section) (jointly with Society of Chemical Industry, Edinburgh and East of Scotland Section) (at North British Station Hotel, Edinburgh), at 7.30.—R. B. Pilcher: Alchemists and Chemists in Art and Literature.

INSTITUTION OF ELECTRICAL ENGINEERS (Dundee Sub-Centre) (at University College, Dundee), at 7.30.—J. K. Murray: Some Features of Telegraph Engineering.

OPTICAL SOCIETY (at Imperial College of Science), at 7.30.—Col. H. S. Winterbotham, Lt.-Col. M. N. MacLeod, and Lt. M. Hotine: Photogrammetric Surveying.

INSTITUTION OF ELECTRICAL ENGINEERS (Irish Centre) (at Trinity College, Dublin), at 7.45.—J. Lindsay: The Mechanical Winning of Peat (Lecture).

SOCIETY FOR CONSTRUCTIVE BIRTH CONTROL AND RACIAL PROGRESS (at Essex Hall, Essex Street, Strand), at 8.—Mme. A. Rieder: Population Problems in the Near East.

OIL AND COLOUR CHEMISTS' ASSOCIATION.

FRIDAY, DECEMBER 11.

ROYAL ASTRONOMICAL SOCIETY, at 5.—O. Struve: A Study of the Nature of Spectroscopic Binaries.—A. S. Williams: A New Variable Star in Andromeda.

PHYSICAL SOCIETY OF LONDON (at Imperial College of Science), at 5.—Dr. E. A. Owen and G. D. Preston: On the Effect of Rolling on the Crystal Structure of Aluminium.—R. S. Burdon: The Spreading of One Liquid on the Surface of Another.—J. T. Combridge: On the Advance of the Perihelion of Mercury.

MALACOLOGICAL SOCIETY OF LONDON (at Linnean Society), at 6.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.

INSTITUTION OF ELECTRICAL ENGINEERS (London Students' Section), at 6.15.—F. J. Lane: The Rotary Converter Automatic Sub-Station.

SOCIETY OF CHEMICAL INDUSTRY (Glasgow Section) (at 39 Elmbank Crescent, Glasgow), at 7.—Open Night.

INSTITUTE OF METALS (Swansea Local Section) (in the Metallurgical Department, University College, Singleton Park), at 7.15.—Prof. J. H. Andrew: Modern Metallurgy.

INSTITUTE OF METALS (Sheffield Local Section) (in the Non-Ferrous Section of the Applied Science Department of the University, St. George's Square), at 7.30.—Prof. F. C. Thompson; Nickel Silver.

JUNIOR INSTITUTION OF ENGINEERS (at Royal Society of Arts), at 7.30.—J. S. Highfield: Presidential Address.

INSTITUTION OF MECHANICAL ENGINEERS (Yorkshire Branch) (at Leeds).—Prof. G. F. Charnock: Chairman's Address.

SATURDAY, DECEMBER 12.

BRITISH PSYCHOLOGICAL SOCIETY (at University College, London), at 3.—J. J. Strasheim: A New Method in Mental Testing.—Miss A. M. Jenkin: Eidetic Imagery.

MINING INSTITUTE OF SCOTLAND (at Glasgow).

PHYSIOLOGICAL SOCIETY (at Bedford College for Women).

PUBLIC LECTURES.

SATURDAY, DECEMBER 5.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Miss M. A. Murray: Travel and Transport in Ancient Egypt.

MONDAY, DECEMBER 7.

SCHOOL OF ORIENTAL STUDIES, at 5.30.—(In French) J. Hackin: Les Monuments bouddhiques et les antiquités musulmanes de l'Afghanistan. (Succeeding Lectures on December 8 and 9.)

UNIVERSITY OF LEEDS, at 8.—Sir Henry Hadow: Chamber Music, illustrated from Beethoven and Modern Composers.

THURSDAY, DECEMBER 10.

KING'S COLLEGE, LONDON, at 5.15.—A. D. Lindsay: Benedict Spinoza.

SATURDAY, DECEMBER 12.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Dr. H. G. Cannon: Floating Life in the Sea.

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Atomic Theory and Mechanics.[1]

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THE CLASSICAL THEORIES.

THE analysis of the equilibrium and the motion of bodies not only forms the foundation of physics, but for mathematical reasoning has also furnished a rich field, which has been exceedingly fertile for the development of the methods of pure mathematics. This connexion between mechanics and mathematics showed itself at an early date in the works of Archimedes, Galileo, and Newton. In their hands the formation of concepts suitable for the analysis of mechanical phenomena was provisionally completed. Since the time of Newton, the development of the methods for treating mechanical problems has gone hand in hand with the evolution of mathematical analysis; we need only recall such names as Euler, Lagrange, and Laplace. The later development of mechanics too, based on the work of Hamilton, proceeded in very close association with the evolution of mathematical methods, the calculus of variations, and the theory of invariants, as appears clearly in recent times also in the papers of Poincaré.

Perhaps the greatest successes of mechanics lie in the domain of astronomy, but in the mechanical theory of heat an interesting application was also found in the course of the last century. The kinetic theory of gases, founded by Clausius and Maxwell, interprets the properties of gases to a large extent as results of the mechanical interactions of atoms and molecules flying about at random. We wish to recall especially the explanation of the two principles of thermodynamics given by this theory. The first principle is a direct result of the mechanical law of conservation of energy, while the second principle, the entropy law, can, following Boltzmann, be derived from the statistical behaviour of a large number of mechanical systems. It is of interest here that statistical considerations have permitted the description not only of the average behaviour of atoms, but also of the fluctuation phenomena, which have led by the investigation of the Brownian motion to the unexpected possibility of counting atoms. The proper tools for the systematic development of statistical mechanics, to which especially Gibbs contributed, were furnished by the mathematical theory of canonical systems of differential equations.

The development of the electromagnetic theories in the second half of last century, following the discoveries of Oersted and Faraday, brought about a profound generalisation of mechanical concepts. Although, to begin with, mechanical models played an essential part in Maxwell's electrodynamics, the advantages were soon realised of conversely deriving the mechanical concepts from the theory of the electromagnetic field. In this theory the conservation laws are explained by considering energy and momentum to be localised in the space surrounding the bodies. In particular, a natural explanation of radiation phenomena can be obtained in this way. The theory of the electromagnetic field was the direct cause of the discovery of electromagnetic waves, which to-day play so important a part in electrical engineering. Further, the electromagnetic theory of light founded by Maxwell provided a rational basis for the wave theory of light, which goes back to Huygens. With the aid of the atomic theory it afforded a general description of the origin of light and the phenomena taking place during the passage of light through matter. For this purpose, the atoms are supposed to be built up of electrical particles which can execute vibrations about positions of equilibrium. The free oscillations of the particles are the cause of the radiation, the composition of which we observe in the atomic spectra of the elements. Further, the particles will execute forced vibrations under the forces in the light waves and thus become centres of secondary wavelets which will interfere with the primary waves and produce the well-known phenomena of reflection and refraction of light. When the frequency of vibration of the incident waves approaches the frequency of one of the free oscillations of the atom, there results a resonance effect, by which the particles are thrown into specially strong forced vibrations. In this way a natural account was obtained of the phenomena of resonance radiation and the anomalous dispersion of a substance for light near one of its spectral lines.

[1] This article represents substantially the contents of an address delivered, on August 30, before the sixth Scandinavian Mathematical Congress in Copenhagen. It should be mentioned, however, that the present elaboration of the text has been notably influenced by the appearance, since the delivery of the address, of an important paper by Heisenberg, to which reference is made below.

Just as in the kinetic theory of gases, it is not merely the average effect of a large number of atoms that comes into consideration in the electromagnetic interpretation of optical phenomena. Thus, in the scattering of light the random distribution of the atoms makes the effects of the individual atoms appear in such a way that a direct counting of the atoms is possible. In fact, Rayleigh estimated from the intensity of the scattered blue light of the sky the number of atoms in the atmosphere, obtaining results in satisfactory agreement with the counting of atoms obtained by Perrin from a study of the Brownian motion. The rational mathematical representation of the electromagnetic theory is based on the application of vector analysis, or more generally tensor analysis of higher dimensional manifolds. This analysis founded by Riemann offered the proper means for the formulation of Einstein's fundamental theory of relativity, which introduces concepts that go beyond Galileo's kinematics, and may perhaps be considered as the natural completion of the classical theories.

The Quantum Theory.

In spite of all the successful applications of mechanical and electrodynamical ideas to atomic theory, further development revealed profound difficulties. If these theories really provide a general description of thermal agitation and of the radiation connected with motion, then the general laws of heat radiation must be capable of a direct explanation. Contrary to all expectations, however, a calculation on this basis could not explain the empirical laws. Going beyond this, Planck demonstrated, retaining Boltzmann's account of the second law of thermodynamics, that the laws of heat-radiation demand an element of discontinuity in the description of atomic processes quite foreign to the classical theories. Planck discovered that in the statistical behaviour of particles which execute simple harmonic oscillations about positions of equilibrium, only such states of vibrations must be taken into account the energy of which is an integral multiple of a "quantum," ωh, where ω is the frequency of the particle and h a universal constant, the so-called Planck's quantum of action.

The more precise formulation of the content of the quantum theory appears, however, to be extremely difficult when it is remembered that all the concepts of previous theories rest on pictures which demand the possibility of a continuous variation. This difficulty was especially emphasised by the fundamental researches of Einstein, according to which essential features of the interaction between light and matter suggest that the propagation of light does not take place by spreading waves but by "light-quanta," which, concentrated in a small region of space, contain the energy $h\nu$, where ν is the frequency of the light. The formal nature of this statement is evident, because the definition and measurement of this frequency rests exclusively on the ideas of the wave theory

Structural Units of the Atom.

This inadequacy of the classical theories was brought into prominence by the development of our knowledge of atomic structure. One formerly hoped that this knowledge might be gradually enlarged by an analysis of the properties of the elements based on the classical theories, which had been fruitful in so many respects. This hope was supported shortly before the birth of the quantum theory by Zeeman's discovery of the effect of magnetic fields on spectral lines. As Lorentz showed, this effect corresponds in many cases to just that action of magnetic fields on the motion of oscillating particles which is to be expected from classical electrodynamics. Besides, this account allowed conclusions to be drawn about the nature of the oscillating particles which agreed beautifully with the experimental discoveries of Lenard and Thomson in the field of electric discharges in gases. As a result, small negatively charged particles, the electrons, were recognised as units common to all atoms. It is true that the so-called "anomalous" Zeeman effect of many spectral lines caused profound difficulties for the classical theory. These were similar to those which showed themselves in the attempts with the aid of electrodynamic models to explain the simple empirical regularities among the spectral frequencies, which were brought to light through the work of Balmer, Rydberg, and Ritz. In particular, such an account of the spectral laws could scarcely be reconciled with the estimate of the number of electrons in the atom which Thomson obtained from observations on the scattering of X-rays by a direct application of the classical theory.

These difficulties could for a time be attributed to our imperfect knowledge of the origin of the forces by which the electrons are bound in the atom. The situation was, however, entirely changed by the experimental discoveries in the field of radio-activity, which furnished new means for the investigation of atomic structure. Thus, Rutherford obtained convincing support for the idea of the nuclear atom from experiments on the passage through matter of the particles ejected by radio-active substances. According to this idea, the greatest part of the atomic mass is localised in a positively charged nucleus, exceedingly small compared with the dimensions of the atom as a whole. Around the nucleus there move a number of light negative electrons. In this way, the problem of atomic structure took on a great similarity to the

problems of celestial mechanics. A closer consideration, however, soon showed that, nevertheless, there exists a fundamental difference between an atom and a planetary system. The atom must have a stability which presents features quite foreign to mechanical theory. Thus, the mechanical laws permit a continuous variation of the possible motions, which is entirely at variance with the definiteness of the properties of the elements. The difference between an atom and an electrodynamic model appears also when one considers the composition of the emitted radiation. For, in models of the sort considered, where the natural frequencies of motion vary continuously with the energy, the frequency of the radiation will change continuously during emission according to classical theory and will therefore show no similarity to the line spectra of the elements.

Quantum Theory of Atoms.

The search for a more precise formulation of the concepts of the quantum theory which might be capable of overcoming these difficulties led to the enunciation of the following postulates:

1. An atomic system possesses a certain manifold of states, the "stationary states," to which corresponds in general a discrete sequence of energy values and which have a peculiar stability. This latter shows itself in that every change in the energy of the atom must be due to a "transition" of the atom from one stationary state to another.

2. The possibility of emission and absorption of radiation by the atom is conditioned by the possibility of energy changes of the atom, in such a way that the frequency of the radiation is connected with the energy difference between the initial and final states by the formal relation

$$h\nu = E_1 - E_2.$$

These postulates, which cannot be explained on classical ideas, seem to offer a suitable basis for the general account of the observed physical and chemical properties of the elements. In particular, an immediate explanation is given of a fundamental feature of the empirical spectral laws. This feature, the Ritz principle of combination of spectral lines, states that the frequency of every line in a spectrum can be represented as the difference between two terms of a manifold of spectral terms characteristic of the element; in fact, we see that these terms can be identified with the energy values of the stationary states of the atom, divided by h. In addition, this account of the origin of spectra gives an immediate explanation of the fundamental difference between absorption and emission spectra. For, according to the postulates, the condition for selective absorption of a frequency which corresponds to the combination of two terms is that the atom is in the state of smaller energy, while for emission of such radiation it must be in the state of greater energy. In short, the picture described is in very close agreement with the experimental results on the excitation of spectra. This is shown especially in the discovery of Franck and Hertz as to impacts between free electrons and atoms. They found that an energy transfer from the electron to the atom can take place only in amounts which are just the energy differences of the stationary states as computed from the spectral terms. In general, the atom is simultaneously excited to emit. Similarly, the excited atom can, according to Klein and Rosseland, lose its emissive power through an impact, and the colliding electron experiences a corresponding increase of its energy.

As Einstein has shown, the postulates also furnish a suitable basis for a rational treatment of statistical problems, especially for a very lucid derivation of Planck's law of radiation. This theory assumes that an atom, which can undergo a transition between two stationary states and is in the higher state, shows a certain "probability," depending only on the atom, of jumping spontaneously to the lower state in a given interval of time. Further, it assumes that external illumination with radiation of the frequency corresponding to the transition gives the atom a probability, proportional to the intensity of the radiation, of going from the lower to the higher state. It is also an essential feature of the theory that illumination with this frequency gives the atom in the higher state, besides its spontaneous probability, an induced probability of jumping down to the lower state.

Quantum Theory of Radiation.

While Einstein's theory of heat radiation gives support to the postulates, it accentuates the formal nature of the frequency condition. For from the conditions for complete thermal equilibrium, Einstein draws the conclusion that every absorption and emission process is accompanied by a transfer of momentum of amount $h\nu/c$, where c is the velocity of light, just as the idea of light quanta would lead one to expect. The significance of this conclusion has been emphasised in a very interesting way by the discovery of Compton that the scattering of homogeneous X-rays is accompanied by a change of wave-length in the scattered radiation depending on the direction of observation. Such a change in frequency follows in a simple way from the light-quantum theory if in the deflexion of the quantum one takes into account the conservation of momentum as well as energy.

The constantly growing contrast between the wave theory of light, apparently required for the explanation

of optical phenomena, and the light-quantum theory, which represents naturally so many features of the interaction between light and matter, suggested that the failure of classical theories may even affect the validity of the laws of conservation of energy and momentum. These laws, which hold so central a position in the classical theory, would, then, in the description of atomic processes, be only statistically valid. However, this suggestion does not offer a satisfactory escape from the dilemma, as is shown by the experiments on the scattering of X-rays which have been undertaken recently with the beautiful methods permitting a direct observation of individual processes. For Geiger and Bothe have been able to show that the recoil electrons and photo-electrons which accompany the production and absorption of the scattered radiation are coupled in pairs just as one would expect from the picture of the light-quantum theory. With the method of the Wilson cloud chamber, Compton and Simon have even succeeded in demonstrating, besides this pairing, the connexion demanded by the light-quantum theory between the direction in which the effect of the scattered radiation is observed and the direction of the velocity of the recoil electrons accompanying the scattering.

From these results it seems to follow that, in the general problem of the quantum theory, one is faced not with a modification of the mechanical and electrodynamical theories describable in terms of the usual physical concepts, but with an essential failure of the pictures in space and time on which the description of natural phenomena has hitherto been based. This failure appears also in a closer consideration of impact phenomena. In particular, for impacts in which the time of collision is short compared to the natural periods of the atom and for which very simple results are to be expected according to the usual mechanical ideas, the postulate of stationary states would seem to be irreconcilable with any description of the collision in space and time based on the accepted ideas of atomic structure.[2]

The Correspondence Principle.

Nevertheless, it has been possible to construct mechanical pictures of the stationary states which rest on the concept of the nuclear atom and have been essential in interpreting the specific properties of the elements. In the simplest case of an atom with only one electron, such as the neutral hydrogen atom, the orbit of the electron would be in classical mechanics a closed ellipse, obeying Kepler's laws, according to which the major axis and frequency of revolution are connected in a simple way with the work necessary for a complete separation of the atomic particles. Now if we regard the spectral terms of the hydrogen spectrum as determining this work, we see in that spectrum evidence of the steplike process through which the electron under emission of radiation is gradually bound more and more firmly in states visualised as orbits of smaller and smaller dimensions. When the electron is bound as firmly as possible, and the atom can therefore emit no further radiation, the normal state of the atom has been reached. The orbital dimensions estimated from the spectral terms have values for this state of the same order of magnitude as the atomic dimensions obtained from the mechanical properties of the elements. From the nature of the postulates, however, such features of the mechanical pictures as frequency of revolution and shape of the electronic orbits are not open to comparison with observations. The symbolic character of these pictures can scarcely be more strongly emphasised than by the fact that in the normal state no radiation is emitted, although according to the mechanical picture the electron is still moving.

Nevertheless, the visualisation of the stationary states by mechanical pictures has brought to light a far-reaching analogy between the quantum theory and the mechanical theory. This analogy was traced by investigating the conditions in the initial stages of the binding process described, where the motions corresponding to successive stationary states differ comparatively little from each other. Here it was possible to demonstrate an asymptotic agreement between spectrum and motion. This agreement establishes a quantitative relation by which the constant appearing in Balmer's formula for the hydrogen spectrum is expressed in terms of Planck's constant and the values of the charge and mass of the electron. The essential validity of this relation was clearly illustrated by the subsequent test of the predictions of the theory regarding the dependence of the spectrum on the nuclear charge. The latter result may be considered as the first step towards the fulfilment of the programme presented by the concept of the nuclear atom, to account for the relationships between the properties of the elements solely by means of the integer which represents the number of unit charges on the nucleus, the so-called "atomic number."

The demonstration of the asymptotic agreement between spectrum and motion gave rise to the formulation of the "correspondence principle," according to which the possibility of every transition process connected with emission of radiation is conditioned by the presence of a corresponding harmonic component in the motion of the atom. Not only do the frequencies of the corresponding harmonic components agree

[2] For a closer discussion of these problems reference may be made to a recent article of the writer; compare in particular the addendum (*Zs. für Phys.* 34, 142, 1925).

asymptotically with the values obtained from the frequency condition in the limit where the energies of the stationary states converge, but also the amplitudes of the mechanical oscillatory components give in this limit an asymptotic measure for the probabilities of the transition processes on which the intensities of the observable spectral lines depend. The correspondence principle expresses the tendency to utilise in the systematic development of the quantum theory every feature of the classical theories in a rational transcription appropriate to the fundamental contrast between the postulates and the classical theories.

The Rules of Quantisation.

The development was considerably furthered by the fact that it seemed possible to formulate certain general laws, the so-called rules of "quantisation," by means of which the mechanical motions associated with the stationary states were to be chosen from the continuous manifold of such motions. These rules concern atomic systems for which the solution of the mechanical equations of motion is simply- or multiply-periodic. In these cases the motion of every particle can be represented as a superposition of discrete harmonic vibrations. According to the rules of quantisation which were considered to be a rational generalisation of Planck's original result for the possible energy values of an harmonic oscillator, certain components of action which characterise the solution of the mechanical equations of motion are put equal to integral multiples of Planck's constant. By means of these rules a classification of the stationary states results in which a set of integers, the "quantum indices," is ascribed to every state. Their number is equal to the degree of periodicity of the mechanical motion.

In formulating the rules of quantisation the modern development of the mathematical methods of dealing with mechanical problems was of decisive importance. We need recall only the theory of phase integrals utilised in particular by Sommerfeld, as well as the property of adiabatic invariance of these integrals emphasised by Ehrenfest. The theory was given a very elegant form by the introduction of the uniformising variables of Stäckel. In this form the fundamental frequencies determining the periodicity properties of the mechanical solution appear as the partial derivatives of the energy with respect to the components of action to be quantised. The asymptotic connexion between the motion and the spectrum as calculated from the frequency condition is secured in this way.

With the help of the rules of quantisation, many finer details of spectra seemed to be accounted for naturally. Of especial interest was Sommerfeld's demonstration, that the small deviations from a Keplerian motion, which result from the modification of Newtonian mechanics demanded by the relativity theory, offer an explanation of the fine structure of the hydrogen lines. Furthermore, we would recall here the explanation given by Epstein and Schwarzschild of the splitting up of the hydrogen lines in an external electric field which Stark discovered. We are here dealing with a mechanical problem, the treatment of which was much improved in the hands of mathematicians like Euler and Lagrange, until Jacobi stated his famous elegant solution by means of Hamilton's partial differential equation. Especially after the utilisation of the correspondence principle—by which not only the polarisation of the Stark effect components was interpreted, but also, as Kramers showed, the peculiar intensity distribution of these components—can we say that in this effect every trait of Jacobi's solution can be recognised, although hidden under a quantum theory mask. In this connexion it is of interest to mention that with the help of the correspondence principle, the effect of a magnetic field on the hydrogen atom could be treated so as to show a far-reaching similarity with Lorentz's account of the Zeeman effect on the basis of classical electrodynamics, especially in the form given by Larmor.

Stability of Atomic Structure.

While the last-mentioned problems represent direct applications of the rules of quantisation, we meet, in the problem of the structure of atoms with several electrons, a case where the general solution of the mechanical problem does not possess the periodic properties which seem to be necessary for the mechanical picturing of the stationary states. It suggested itself, however, that this further limitation of the applicability of mechanical pictures in the study of the properties of atoms with several electrons, beyond that in the study of atoms containing only one electron, is directly connected with the postulate of the stability of stationary states. In fact, the interaction of the electrons in the atom presents a problem which is quite analogous to the problem of a collision between an atom and a free electron. Just as no mechanical explanation can be given for the stability of an atom in the collision, so we must suppose that already, in the description of the stationary states of the atom, the special part which every electron plays in its interaction with the other electrons is secured in an entirely unmechanical way.

This view is in general conformity with the spectroscopic evidence. An important feature of this evidence is the discovery of Rydberg, that in spite of the more complicated structure of the spectra of other elements compared to that of hydrogen, the same constant as that in the Balmer formula appears in the empirical formulæ of the series spectra of all elements. This discovery is simply explained by regarding the series spectra as evidence of processes by which an electron is added to an atom, its binding becoming more firm step by step with the emission of radiation. While the character of the binding of the other electrons remains the same, the steplike strengthening of the binding of this electron is visualised by orbits which at first are large compared with usual atomic dimensions, and become smaller and smaller until the normal state

of the atom is reached. In the case when the atom has a single positive charge before the capture of the electron, the attraction of the electron by the rest of the atom will, on this picture of the binding process, at first coincide closely with the attraction of the particles in the hydrogen atom. It is therefore clear why the spectral terms representing the binding of the electrons show an asymptotic convergence to the terms of the hydrogen spectrum. In the same way one obtains a direct explanation of the general dependence of a series spectrum on the state of ionisation of the atom, brought to light so beautifully through the work of Fowler and Paschen.

Typical evidence of the way in which the electrons are bound in the atoms is also afforded by the study of the X-ray spectra. On one hand, the fundamental discovery of Moseley, of the striking similarity of the X-ray spectrum of an element to the spectrum that corresponds to the binding of a single electron by the nucleus, can be easily understood if it is remembered that in the interior of the atom the direct influence of the nucleus on the nature of the binding of each individual electron exceeds greatly the mutual influence of the electrons. On the other hand, the X-ray spectra show certain characteristic differences from the series spectra. These originate from the circumstance that in the former we do not witness the binding of an additional electron in the atom, but the reorganisation of the binding of the remaining electrons upon removal of one of the electrons previously bound. This circumstance, which has been especially emphasised by Kossel, was well suited for bringing to light new and important features of the stability of atomic structure.

The Analysis of Spectra.

To account for the details of the spectra, a closer study of the interplay of the electrons in the atom is, of course, required. Disregarding a strict application of mechanics, an attack was made on this problem by assigning to every electron a motion of such periodic properties that a classification of the spectral terms by means of quantum indices could be accomplished. In the hands of Sommerfeld, in particular, a number of regularities of spectra were simply explained in this way. Further, these considerations afforded a fruitful field of application for the correspondence principle. In fact, this gave an account of the peculiar limitations in the possibilities of combining spectral terms, the so-called selection rules for spectral lines.

On these lines, it has recently been possible by making use of the evidence from series spectra, as well as from X-ray spectra, to draw conclusions about the grouping of electrons in the normal state of the atom. This grouping explained the general features of the periodic system of the elements in conformity with the ideas of chemical activity of atoms as developed especially by J. J. Thomson, Kossel, and G. N. Lewis. Progress in this field has been intimately connected with the great enrichment during the last few years of spectroscopic evidence, and, not least, by the investigations of Lyman and Millikan, the gap has been almost bridged over between the optical spectra and the region of X-rays, where great advances have been made in recent years by Siegbahn and his collaborators. In this connexion the work of Coster on the X-ray spectra of heavy elements may be mentioned as affording beautiful support for the account of essential features of the periodic system.

The analysis of the finer details of the spectra, however, has brought to light a number of features which could not be interpreted with mechanical pictures on the basis of the theory of periodicity systems. We refer in particular to the multiplet structure of spectral lines and the effect of magnetic fields on these structures. These latter phenomena, which are generally known as anomalous Zeeman effects and, as mentioned above, had already led to difficulties in the classical theories, fitted, it is true, in a natural way into the scheme of the fundamental postulates of the quantum theory. For, as Landé showed, the frequencies of the components into which each spectral line is split up by the field can, like the original lines, be represented as combinations of terms. The manifold of these magnetic terms is obtained by replacing each original spectral term by a set of values which differ from it by small quantities depending on the field intensity. In fact, the beautiful experiments of Stern and Gerlach, by which a direct connexion was established between the force which acts on an atom in a non-homogeneous magnetic field and the energy values of the stationary states in the field calculated from the magnetic terms, may be regarded as a most direct support of the fundamental ideas of the quantum theory.

Landé's analysis discloses, however, a strange difference between the interactions of the electrons in the atom and the coupling of mechanical systems. In fact, we are forced to assume the presence of a mechanically undescribable "strain" in the interaction of the electrons which prevents a unique assignment of quantum indices on the basis of mechanical pictures.[3] In the discussion of this problem a general condition of thermodynamic stability introduced by Ehrenfest played an important part. When applied to the postulates of the quantum theory, this condition states that the statistical weight attributed to a stationary state is a quantity which cannot be changed by a continuous transformation of the atomic system. Moreover, it has recently been recognised that this same condition leads, even for atoms with only one electron, to difficulties which point to a limitation of the validity of the theory of periodicity systems. In fact, the problem of the motion of point charges admits of certain singular solutions which must be excluded from the manifold of stationary states. This exclusion artificially restricts the rules of quantisation, but at first this restriction did not obviously contradict experimental evidence. Difficulties of an especially grave nature, however, were brought to light by the interesting analysis by Klein [4] and Lenz [5] of the problem of a hydrogen atom in crossed electric and magnetic fields. Here it was found impossible to satisfy Ehrenfest's condition, since suitable variation of the external

[3] Compare an article of the writer (*Ann. d. Phys.* 71, 228, 1923) which contains a general survey of the results regarding the explanation of spectral evidence on the basis of mechanical pictures of stationary states. In this article detailed reference to the earlier literature on the subject may be found, and we therefore have confined ourselves here to quoting papers which have appeared since then.

[4] O. Klein, *Zs. für Phys.* 22, 109, 1924.

[5] W. Lenz, *Zs. für Phys.* 24, 197, 1924.

forces would gradually transform orbits depicting stationary states which could not always be excluded from the manifold of these states, into orbits where the electron falls into the nucleus.

Apart from these difficulties, the analysis of the finer details of the spectra has considerably furthered the quantum theory interpretation of the laws of the relationship between the elements. In fact, an extension of the ideas regarding the grouping of the electrons to which the quantum theory has led has recently been suggested by Dauvillier,[6] Main Smith,[7] and Stoner,[8] taking various kinds of evidence into consideration. Notwithstanding the formal nature of these suggestions, they exhibit a close connexion with the spectral regularities disclosed by Landé's analysis. In this direction important progress has recently been made, especially by Pauli.[9] Notwithstanding that the results thus obtained constitute an important step towards the above-mentioned programme of accounting for the properties of the elements solely on the basis of the atomic number, it must be remembered, however, that the results do not allow of a unique association with mechanical pictures.

Quantum Theory and Optical Phenomena.

A new era in the development of the quantum theory has been opened up during the last few years by a closer study of optical phenomena. While, as mentioned above, the classical theory had such great successes in this field, the postulates at first gave no direct clue. From experiment, it is true, one could conclude that an atom, when illuminated, caused a scattering of the light essentially analogous to the classically computed scattering of elastically bound electrical particles, the natural frequencies of which are the same as the frequencies corresponding to the transition processes which the atom can perform under the influence of external radiation. In fact, on the classical theory such harmonic oscillators would, when excited, emit a radiation of just the same constitution as that of atoms transferred to a higher stationary state.

The possibility of obtaining a unified description of optical phenomena with this concept of oscillators conjugated to the transitions was essentially advanced by an idea of Slater,[10] according to which the emission of radiation from an activated atom may be regarded as "cause" for the spontaneous transitions, in analogy to the effect of incident radiation in producing transitions. Ladenburg made a first important step towards a quantitative description of dispersion by suggesting a definite connexion between the scattering activity of the oscillators and the probabilities of the corresponding transitions in Einstein's theory. Decisive progress, however, was made by Kramers[11] by an ingenious transcription in harmony with the correspondence principle of the effects which, according to classical theory, are brought about in an electrodynamical system by illumination with light waves. Just as the radiation frequencies are calculated in the classical theory, on one hand, and the quantum theory on the other hand, it is typical in this transcription, that differential quotients are replaced by differences, in such a way that in the final formulæ only quantities open to direct observation appear. Thus in Kramers' theory the scattering of an atom in a certain stationary state is quantitatively connected with the frequencies corresponding to the different transition processes to other stationary states as well as to the probabilities of the appearance of these transitions under the influence of illumination.

It is an essential feature of the theory that in calculating the anomalous dispersion near a spectral line, one has to take into account two opposite kinds of resonance effects depending on whether the spectral line corresponds to a transition of the atom to a state of larger or smaller energy. Only the first of these corresponds with the resonance effects which have been utilised previously in accounting for dispersion on the basis of the classical theory. It is also very interesting that the further development of the theory by Kramers and Heisenberg[12] gave a natural quantitative description of additional scattering effects with changed frequencies, the existence of which had been predicted by Smekal[13] from considerations based on the theory of light quanta, which thereby again has shown its fertility.

While this description of optical phenomena was entirely in harmony with the fundamental ideas of the quantum theory, it soon appeared that it stood in strange contradiction to the use of the mechanical pictures previously employed for an analysis of the stationary states. In the first place, it is impossible on the basis of the scattering activity of illuminated atoms demanded by the dispersion theory to construct an asymptotic connexion between the reaction of an atom in alternating fields of smaller and smaller frequency and the reaction in constant fields as calculated from quantisation rules of the theory of periodicity systems. This difficulty strengthened the doubts about this theory to which, as already mentioned, the problem of the hydrogen atom in crossed electric and magnetic fields had led. Secondly, it had to be regarded as especially unsatisfactory that the theory of periodicity systems was apparently helpless in the problem of the quantitative determination of the transition probabilities on the basis of the mechanical pictures of stationary states. This was felt all the more, as it was possible in several cases to obtain a quantitative formulation of the general statements of the correspondence principle as regards these transition probabilities with the help of viewpoints suggested by an analysis of the optical behaviour of electrodynamic models.[14] These results stood in excellent agreement with measurements on the relative intensities of spectral lines, as they have been developed especially in Utrecht

[6] A. Dauvillier, *C.R. Acad. Sci.*, 177, 476, 1924.
[7] J. D. Main Smith, *Journ. Chem. Ind.*, 44, 944, 1925.
[8] E. C. Stoner, *Phil. Mag.*, 48, 719, 1924.
[9] W. Pauli, Jr., *Zs. für Phys.* 31, 765, 1925. Compare also H. N. Russell and F. A. Saunders, *Astrophys. Journ.*, 61, 38, 1925; S. Goudsmit, *Zs. für Phys.* 32, 794, 1925; W. Heisenberg, *Zs. für Phys.* 32, 841, 1925; F. Hund, *Zs. für Phys.* 33, 345; 34, 296, 1925.
[10] J. C. Slater, NATURE, 113, 307, 1924; see also N. Bohr, H. A. Kramers and J. C. Slater, *Phil. Mag.*, 47, 785, 1925.
[11] H. A. Kramers, NATURE, 113, 673; 114, 310, 1924.
[12] H. A. Kramers and W. Heisenberg, *Zs. für Phys.* 31, 681, 1925.
[13] A. Smekal, *Die Naturwissenschaften*, 11, 873, 1923.
[14] H. C. Burger and H. B. Dorgelo, *Zs. für Phys.* 23, 258, 1924; L. S. Ornstein and H. C. Burger, *Zs. für Phys.* 24, 41; 28, 135; 29, 241, 1924; W. Heisenberg, *Zs. für Phys.* 31, 617, 1925; S. Goudsmit and R. de L. Kronig, *Die Naturwissenschaften*, 13, 90, 1925; H. Hönl, *Zs. für Phys.* 31, 340, 1925; R. de L. Kronig, *Zs. für Phys.* 31, 885; 33, 261, 1925; A. Sommerfeld und H. Hönl, *Ber. Berlin. Akad.* 141, 1925; H. N. Russell, NATURE, 115, 835, 1925.

during the last few years, but they could only in a very artificial way be included in the schemes governed by the rules of quantisation.

An Attempt at a Rational Quantum Mechanics.

Quite recently Heisenberg,[15] who has especially emphasised these difficulties, has taken a step probably of fundamental importance by formulating the problems of the quantum theory in a novel way by which the difficulties attached to the use of mechanical pictures may, it is hoped, be avoided. In this theory the attempt is made to transcribe every use of mechanical concepts in a way suited to the nature of the quantum theory, and such that in every stage of the computation only directly observable quantities enter. In contrast to ordinary mechanics, the new quantum mechanics does not deal with a space-time description of the motion of atomic particles. It operates with manifolds of quantities, which replace the harmonic oscillating components of the motion and symbolise the possibilities of transitions between stationary states in conformity with the correspondence principle. These quantities satisfy certain relations which take the place of the mechanical equations of motion and the quantisation rules.

That such a procedure actually leads to a self-contained theory sufficiently analogous to classical mechanics depends essentially on the fact that, as Born and Jordan[16] were able to show, there exists in Heisenberg's quantum mechanics a conservation theorem analogous to the energy law of classical mechanics. The theory is built up in such a way that it is automatically in harmony with the postulates of the quantum theory. In particular, the frequency condition is fulfilled by the values for energies and frequencies derived from the quantum mechanical equations of motion. Although the fundamental relations which take the place of the quantisation rules involve Planck's constant, quantum indices do not appear explicitly in these relations. The classification of stationary states is based solely on a consideration of the transition possibilities, which enable the manifold of these states to be built up step by step. In brief, the whole apparatus of the quantum mechanics can be regarded as a precise formulation of the tendencies embodied in the correspondence principle. It must here be mentioned that the theory fulfils the requirements of Kramers' dispersion theory.

Owing to the great difficulties of the mathematical problem involved, it has not yet been possible to apply Heisenberg's theory to questions of atomic structure. From the above brief description it will be understood, however, that a number of results, which, like the expression for Rydberg's constant, had formerly been obtained on the basis of mechanical pictures by the aid of the correspondence principle, will retain their validity.[17] Moreover, it is of the greatest interest that already in the simple cases for which up to now a treatment on the basis of Heisenberg's theory has been carried out, the new theory leads, besides, to a quantitative calculation of the transition probabilities and to energy values for the stationary states, which differ systematically from those obtained by the quantisation rules of the older theory. One may therefore hope that Heisenberg's theory will be helpful in the struggle with the puzzling difficulties, mentioned above, in the study of the finer details of the spectra.

Earlier in this paper mention was made of the fundamental difficulties involved in the construction of pictures of the interaction between atoms either by means of radiation or by collisions. These difficulties seem to require just that abandoning of mechanical models in space and time which is so characteristic a feature in the new quantum mechanics. As yet, however, the formulation of this mechanics takes no account of the coupling of transition processes in pairs which shows itself in those interactions. In fact, only those quantities which depend on the existence of the stationary states and the possibilities of transitions between them occur in the new theory, which definitely avoids any mention of the times at which transitions take place. This restriction, however, which is typical of the attack on the problem of the constitution of the atom based on the postulates of the quantum theory, allows only some aspects of the analogy between the quantum theory and the classical theories to come to light. These aspects belong principally to the radiative properties of atoms, and just here Heisenberg's theory represents a real advance. In particular it allows us, in the phenomena of scattering, to recognise the presence of electrons bound in atoms in a way completely analogous to the classical theories,[18] which, as stated above, in the hands of J. J. Thomson enabled the number of electrons in an atom to be counted from measurements of scattering of X-rays. The problems arising out of the validity of the conservation laws in atomic interaction involve, however, quite other aspects of the correspondence of the quantum theory with the classical theory. These are equally essential in the general formulation of the quantum theory and it is impossible to avoid discussing them when the reaction of atoms to swiftly moving particles is more closely studied. It is just here indeed that the classical theories have contributed so fundamentally to our knowledge of atomic structure.

It will interest mathematical circles that the mathematical instruments created by the higher algebra play an essential part in the rational formulation of the new quantum mechanics. Thus the general proofs of the conservation theorems in Heisenberg's theory carried out by Born and Jordan are based on the use of the theory of matrices, which go back to Cayley and were developed especially by Hermite. It is to be hoped that a new era of mutual stimulation of mechanics and mathematics has commenced. To the physicists it will at first seem deplorable that in atomic problems we have apparently met with such a limitation of our usual means of visualisation. This regret will, however, have to give way to thankfulness that mathematics, in this field too, presents us with the tools to prepare the way for further progress.

[15] W. Heisenberg, *Zs. für Phys.* 33, 879, 1925.

[16] M. Born and P. Jordan, *Zs. für Phys.*, to appear shortly. The writer is obliged to the authors for the opportunity of seeing their paper in proof.

[17] *Note added in proof.* Dr. Pauli has very kindly informed me of his success in making the new theory account quantitatively for the Balmer formula for the hydrogen spectrum as well as the influence on this spectrum of electric and magnetic fields. This is a very important result, since Pauli's analysis shows how the new theory avoids the difficulty involved in the older account of the spectral evidence in the necessary exclusion of the stationary states corresponding to singular solutions of the electronic motion.

[18] Compare H. A. Kramers, *Physica*, Dec. 1925.

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