NATURE

SATURDAY, JUNE 9, 1923.

CONTENTS.

Editorial and Publishing Offices :
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.

Telegraphic Address: PHUSIS, LONDON.
Telephone Number: GERRARD 8830.

NO. 2797, VOL. 111]

Medical Education in England.

IN a memorandum of nearly two hundred pages, addressed to the Minister of Health, Sir George Newman has reviewed some of the recent advances in medical education in England.[1] The occasion is timely. Never before has there been such an urgency and expectation of reforms; never, as since the War, such general appreciation of the vast potentialities of medical science in determining the society of the future. There is no medical school in Britain but has felt reinvigorated by the general sense of change and movement forwards. Like the celestial shades, Benevolence and Gratitude, in Tourguenieff's amusing satire, Science and Practice have been made acquainted. Of all the heavenly company they alone did not know each other before. Congratulation is free and happy; it is part of the new atmosphere of hope and fresh resolve.

Since the publication of an earlier memorandum in 1918 "there have been significant developments in Medical Education" in England, and medical education in England was, on the whole, ahead of the rest of the world already. Probably this last is a fair summary of the facts as they are presented here, not by Sir George Newman alone, but by a host of industrious correspondents, in great wealth of detail, albeit from diverging points of view. Darwin and Huxley among the naturalists, Shakespeare, Keats, and Wordsworth among the poets, are requisitioned to point the moral of Sir Clifford Allbutt, who has said that "at this moment it is revealed to us that Medicine has come to a new birth. . . . What is then this new birth, this revolution in Medicine? It is nothing less than its enlargement from an art of observation and empiricism to an applied science founded upon research; from a craft of tradition and sagacity to an applied science of analysis and law; from a descriptive code of surface phenomena to the discovery of deeper affinities; from a set of rules and axioms of quality to measurements of quantity."

The new knowledge came in almost bewildering succession—cell changes, toxins, immunology, asepsis, internal secretion, cardiology. "The medical man may now be, if he will, master of his fate"; and we know that this jubilation is scarcely in excess or ill-founded. We know that chemistry and physics have served the physiologist nobly and untiringly; that an enlightened anatomy, liberated from the narrow specialism of the dead-house, is rising to its old command of all biological problems; that British physiology

[1] "Recent Advances in Medical Education in England." A Memorandum addressed to the Minister of Health by Sir George Newman, Chief Medical Officer of the Ministry of Health and of the Board of Education. (London: H.M. Stationery Office, 1923. 1s. 3*d*. net.)

adds still to unequalled conquests; that "integration" in medicine has at least begun.

Why, then, should we turn from Sir George Newman's remarkable document dissatisfied and oppressed? It is not primarily the wealth of medical knowledge that is Sir George Newman's theme, but the problem of student inheritance. It may be true that "the most after all that can be accomplished . . . is to provide him with the tools of learning in order that by experience he may become a reliable and effective workman." It is true, if by "tools of learning" is meant something which, though vague, is positively and certainly immeasurably short of his ultimate attainment as a representative physician or surgeon, or an efficient general practitioner. In the most that can be accomplished is room for widely divergent ideals and attitudes. "Science," writes Dr. Bateson, "is not a material to be bought round the corner by the dram, but the one permanent and indispensable light in which every action and every policy must be judged. . . . The splendid purpose which Science serves is the inculcation of principle and balance, not facts."

Is this sentiment, so ingrained in the outlook of the man of science who necessarily looks forwards and away from the already known, a safe approach to the discussion of the adventitious and the merely academic in the medical curriculum? Over and over again it is borne in upon us that the medical student is the veriest beast of intellectual burden. The biologist writes threateningly that "if the medical man is not a biologist, he is nothing," while it is admitted that "what is necessary is a widening of the basis, less imposition of details on the memory of the student, and an introduction to scientific thought and method." In chemistry "the amount of detail imposed upon the student in didactic lectures is still perhaps too great." Anatomy "has been robbed of its heritage and reduced to the routine and detailed analysis of a scrapped machine, and the only goal has all too frequently been the examination test." The past student of anatomy was "overburdened with a multiplicity of detail, wearied with bone classes and a hundred systematic lectures, and harassed by meticulous examinations for which he is driven to prepare himself by 'cramming.'" Even in medicine and surgery "the student is overfed for his size." He attempts to learn, merely for examination purposes, much that is of little value, yet fails completely to master the simpler knowledge and manipulations which may fall to his lot frequently. How could it be otherwise when the prestige of famous schools depends upon pass lists and distinction lists, and not by any means upon the "inculcation of principle and balance" which only life, "never overlooking a mistake or making the smallest allowance for ignorance," can test? Much as the fame of some of them deserves to be founded in the breadth and distinction and power to influence of their teachers, that is the case in scarcely one. "At present, in spite of the reasonableness, high competency and goodwill of the examiners, the system remains a shackle upon medical education."

Sir George Newman offers two remedies for this malady. The first is time and the natural order of events, a necessary element, doubtless, in every advancement. The second is the acquisition of a more practical outlook throughout the training of the student. His science should be applied science. We wonder whether the historical and, as it were, developmental setting in which Sir George Newman has cast his study has not misled him there. Is the progress of medicine really an orderly progress as of one body? The point is sharpened by Prof. Halliburton, to whose views the memorandum gives assent. "I venture to think," he says, "that not infrequently the fault lies not with the physiological teacher, but with the hospital physician. . . . The physician, after an inadequate study of the science of physiology in the remote past, may have lost all touch and sympathy with the science of to-day, may have sunk into an easy empiricism, and may be content to cloak his ignorance by sneers at the application of scientific methods to practice." Thoughtful students have themselves recognised (or suspected) that it was there the bottom fell out of their curriculum. They had been taught to expect too much from practice: had confused applied science with the application of scientific methods. Sir George Newman regards the antithesis between the practical man and the inquiring man as false. But it is not false. It lies at the root of all the present difficulties of medical education. The "clinical unit" system—a genuine device of integration—may do much to resolve it; but confusion of thought in regard to it will prove the most dangerous obstacle to that great reform in medicine which now opens before us so hopefully.

British Coal-Mining in the War Period.

The British Coal-Mining Industry during the War. By Sir R. A. S. Redmayne. (Economic and Social History of the World War, British Series. Published on behalf of the Carnegie Endowment for International Peace.) Pp. xv + 348. (Oxford: Clarendon Press; London: Oxford University Press, 1923.) 10*s*. 6*d*. net.

SIR RICHARD REDMAYNE is to be congratulated upon having produced a work of quite exceptional interest; the history of the means by which the British coal supply, upon which our chances of victory so greatly depended during the War, was maintained, must necessarily be interesting, but it becomes even more so when it is told by one who himself played a leading part in this strenuous work. In no other way would it have been possible for the public to gain even an insight into the elaborate and complex operations that were required in order to maintain the output of this indispensable fuel through the whole of that trying and anxious time.

The inception of the present book is somewhat curious; it is published under the auspices of the Carnegie Endowment for International Peace, in pursuance apparently of a theory that the best way to prevent wars in the future is to explain all the details necessary to carry them on successfully. Whatever may be thought of this proposition, it has certainly given occasion for the publication of matter of the highest interest. Sir Richard's narrative is chronological, the leading events of each year, so far as the subject of coal supply is concerned, being grouped together. For much of what he has written he is and must remain the sole authority, but it can fairly be said that the description sounds very straightforward, and leaves on the reader's mind a convincing impression of impartial accuracy. Coal control necessarily bulks very largely, and it need scarcely be said that Sir Richard writes of coal control from the point of view of one of the controllers; it would no doubt have been an immense advantage to have had a companion chapter written by one of the controlled. The harrow appears to be remarkably well pleased with itself, but it is just possible that the toad may not be quite so appreciative.

Sir Richard is of the opinion that upon the whole the coal control worked well; and although it has been severely criticised in many quarters, the subject is so complex that it is difficult to see how any system could have been devised that would not be liable to many grave objections. Sir Richard, indeed, almost hints at defects when he points out, as he does in more than one passage, that direct financial control of the collieries might well have been avoided had it not been for the turbulence, selfishness, and disloyalty of one section of the industry—the coal miners of South Wales; he seems to think that their attitude rendered direct control absolutely necessary.

In appointing the coal controller it was possibly right to select a man of business ability and the power of organisation and administration rather than one possessed of technical knowledge and experience in coal production; but even though this may have been sound policy, it was certainly wrong to have chosen for his subordinates, for the men with whom the colliery manager would come into direct contact, so many who were unacquainted with mining matters. When a colliery manager found that the representative of the coal control, to whom he had to state his case and to whom the decision even in matters of great importance appeared often to be left, was absolutely ignorant of the elements of the mining industry, he naturally lost faith in the Department, and the coal control fell into disfavour, which could have been largely avoided had the subordinate executive of the coal control known more about coal mining. It may possibly not be true that the colliery manager who asked for a new winding rope 300 fathoms long was informed that the Department could not grant him more than 150 fathoms, or that a request addressed to the coal control for washed nuts was referred to the food controller; but the mere fact that such stories were current shows well enough how little confidence the coal control department succeeded in inspiring into the coal trade.

Necessarily, the doings of the coal control and the various sub-departments into which it was divided make up the greater part of the book, but probably to many readers the final chapter, in which Sir Richard summarises the economic history of the coal industry and gives the conclusions which he himself draws from this review, will be the most interesting. At the present moment it is perhaps most important to point out that Sir Richard's views have matured since he gave his evidence before the Sankey Commission; he there carefully avoided expressing any decided views on the nationalisation of collieries, and went so far as to say that in his opinion no man can say whether mines would be as efficiently run if they are centralised and run as a national concern as they are under present conditions. Now he writes very differently: "Complete freedom of action for those engaged in the management is absolutely essential to the successful conduct of so highly organised and technical an industry as that of coal-mining. Where an industry has to be conducted under a great diversity of conditions the edicts of a central authority stand in constant need of modification as they are applied to particular cases. Otherwise work will be conducted wrong-headedly and in defiance of material facts. True as this is of all great industrial concerns, it is particularly so in the case of mining." "Whatever results may accrue from such a policy [*i.e.* nationalisation], from the record of observation I find great difficulty in believing that it would make for efficiency. . . . Even if nationalised control were not vetoed by the inherent physical difficulties of the case, it would still have the disadvantage of removing from the industry the great energising forces of personal responsibility and initiative."

If this book did nothing else than record in such unmistakable language Sir Richard's adhesion to the views that have been expressed by practically every one experienced in the technical administration of collieries, it would serve a most useful purpose at the present moment; but in addition it presents, as has been indicated, an inside view of one of the most complex of the various emergency administrations developed by the stress of war conditions, and forms a document which no student of industrial economics can afford to neglect.

H. LOUIS.

The Structural Units of the Body.

Emil Fischer—Gesammelte Werke. Herausgegeben von M. Bergmann. *Untersuchungen über Aminosäuren, Polypeptide und Proteine II.* (1907–1919). Von Emil Fischer. Herausgegeben von M. Bergmann. Pp. ix + 922. (Berlin: Julius Springer, 1923.) 24*s.* 2*d.*

AT the beginning of the twentieth century knowledge of the nitrogenous constituents of the body lagged far behind that of the fats and sugars, and the information available as to the composition and structure of the various forms of protein was of the scantiest. Within five years a complete change in this respect was effected as the result of the labours of Emil Fischer and his pupils—not only were the constituents of the proteins almost completely identified both qualitatively and quantitatively, but also the artificial synthesis of most of the individual units was effected, and the first steps taken towards their coupling together to form polypeptides.

Fischer's pioneer work on the amino acids, polypeptides, and proteins commenced just prior to his taking possession of the new laboratories in the Hessischestrasse, Berlin, about 1899, and during the next six years this was his main work: he republished his collected papers in 1906. Dr. Bergmann has now collected the further publications in this series up to 1916: they amount to a stately volume of 892 pages. During the last few years of his life Fischer worked in the main at problems in sugar chemistry, but he always spoke of his intention to return to investigations of the proteins.

The papers reprinted in the volume before us fall naturally into four classes—the investigation of the individual amino acids which form the units from which the proteins are built up, the synthesis of polypeptides of ever-increasing structural complexity from the amino acids, the investigation of the degradation products of protein hydrolysis, and the study of the remarkable so-called Walden rearrangement of groups attached to asymmetric carbon atoms, which takes place during a variety of relatively simple chemical reactions. The value of the collected papers as a work of reference is materially enhanced by a carefully prepared index.

Fischer's work in these fields is in many ways typical not only of the man himself but also of the German method. The problem was attacked thoroughly, methodically, and systematically, with all the resources of a great and newly-equipped laboratory; an adequate number of trained assistants were available, funds were not lacking, and the time of the professor himself was not too much occupied by routine and administrative work, which could be performed equally well by a less gifted individual. Publication was prompt, and could be secured without that friction with editorial committees which is so destructive of enthusiasm.

In all, nineteen amino acids have been separated as products of protein hydrolysis. Glycocoll was isolated so far back as 1820 by Braconnot, who obtained it from gelatin, together with leucine, which Proust had found two years earlier in cheese. Oldest of all is cystine, the only protein constituent containing sulphur in its molecule, which was discovered in 1810 by Wollaston. Fischer added proline and oxyproline to the list in 1901–2, and discovered the more complex diaminotrioxydodecanic acid in 1904. Hopkins and Cole isolated tryptophane in 1901. The amino acids typify all classes of acids: normal paraffins, aromatic analogues and their hydroxy derivatives, dicarboxylic acids, heterocyclic pyrrolidine compounds, imidazols, indols, and lastly diamino substances. They occur in the proteins as optically active forms, and have mostly been synthesised in this form.

Having fully characterised the amino acids, Fischer's next step was to devise methods of coupling them together, at first in pairs, to form what he named dipeptides, and afterwards in increasing numbers until a molecule approximating in complexity to the actual protein was obtained. It will be evident that the number of possible isomerides of such compounds obtained by altering the order in which the various amino acids are linked together is very large. Thus for an octadecapeptide synthesised by Fischer from 15 molecules of glycine and 3 molecules of lysine there are 816 possible different methods of arrangement. Judging from the results of the analysis of the products of the partial hydrolysis of the natural proteins, they never contain long chains of a single amino acid, but are highly complex, each following link in the chain being a different acid. In this respect there is a resemblance to the fats, the natural compounds being in the main mixed glycerides containing several fatty acid radicles. As a consequence the number of possible isomerides of a product having the structure of casein is enormous. When our methods are more refined, such minor variations may possibly serve to explain the differences between the caseins derived from the milk of various animals and the highly specific behaviour of various proteins in immunity tests. Of outstanding importance is the fact that the synthetic products are attacked by those enzymes which normally effect protein digestion. Material is thus afforded for the systematic study of the fermentative processes in the organism, and it may be claimed that the chemist has gone a long way to meet the physiologist on common ground.

The synthesis of the type protein may be said to have been accomplished by Fischer, but the synthesis of an actual protein is quite another matter, and least of all will it ever be possible economically to make synthetic protein at a price to compare with the product of the vegetable world. Alike with sugar, fat, and protein, it is the problem of man so to increase yield, and maybe quality as well as quantity, as to provide a sufficiency of cheap food for our needs. The application of chemical knowledge to agriculture and to horticulture in ever-increasing intensity is not the least important of our tasks.

At the moment of putting down this monumental work, with more than a pang of sorrow that its author has passed beyond, one cannot help the involuntary comparison with an entirely different type of chemist of our own race—Sir James Dewar. Fischer, the patient, untiring observer and investigator in the organic laboratory, never allowing himself to deviate from his plan. Dewar, all genius and impatience, full of daring, an artist above all both in his science and his spirit.

E. F. ARMSTRONG.

Actuarial Mathematics.

(1) *Calculus and Probability for Actuarial Students.* By A. Henry. (Published by the Authority of and on Behalf of the Institute of Actuaries.) Pp. vii + 152. (London: C. and E. Layton, 1922.) 12*s.* 6*d.*

(2) *Life Contingencies.* By E. F. Spurgeon. (Published by the Authority and on Behalf of the Institute of Actuaries.) Pp. xxvii + 477. (London: C. and E. Layton, 1922.) 30*s.*

(1) MR. HENRY'S volume contains a course of differential and integral calculus, coupled with finite differences, designed primarily to meet the requirements of actuarial students. Stress is laid throughout on the numerical methods with which actuaries are mainly concerned. The treatment of the differential and integral calculus suffers from lack of rigour and would not satisfy a modern pure mathematician. It contains nothing, however, likely to mislead those whose main interest lies in the numerical applications.

The eight chapters on finite differences give all the most useful rules for interpolation, both direct and inverse. A numerical example, to evaluate $f(2\cdot33333)$, given $f(2\cdot30103)=200$, $f(2\cdot32222)=210$, $f(2\cdot34242)=220$, $f(2\cdot36173)=230$, is worked out by four methods which lead to the same result, 215·442. Such illustrations as this tend to increase the faith of a reader sceptical about the validity of the formulæ. The section on integral calculus contains a useful chapter on approximate numerical integration including the formulæ of Lubbock, Woolhouse, Simpson, Weddle, and G. F. Hardy. A chapter on probability and a collection of examples conclude the volume. Mr. Henry's book is one which can be strongly recommended, not only to actuarial students, but to all whose work lies in the numerical applications of the calculus and finite differences.

(2) The second volume before us is issued as the "official" text-book on life contingencies. It discusses mathematically such subjects as mortality tables and their statistical application, probabilities of life and death, and all the usual types of assurance and annuity. A mortality table, on which the calculation of assurance data rests, is necessarily constructed from experimental evidence: it gives the number of people, among N aged n years, who may be expected to attain the age of $n+x$ years. The usual tables are: (1) English life tables compiled from census returns and death registers, (2) tables compiled from the experience of British life offices, relating to the *select* class of lives with which the companies have dealt, and (3) such tables as Gompertz's and Makeham's, which are based on conjectured theoretical expressions for the functions occurring in a life-table.

Mr. Spurgeon's volume will now be accepted as the standard treatise, so far as the subjects with which it deals are concerned. A reader possessing a fair working knowledge of elementary mathematics, including the calculus and finite differences so far as they are contained in Mr. Henry's companion volume, should be sufficiently prepared to read most of it. The arguments throughout the book are clearly presented, and the theory is illustrated by many solved numerical examples—most of which involve using data supplied by the tables.

We cannot help thinking that the notation adopted for some of the actuarial functions is unfortunate. In certain types of mathematical work a multiple-suffix notation is helpful, but such symbols as

$${}_{t}V^{(m)}_{[x]:\overline{n}|}, \quad {}_{n|}A^{1}_{[x]:\overline{m}|}, \quad {}_{t+\frac{r}{m}}V^{(m)}_{[x]}$$

present considerable difficulties to both printer and

Z 1

reader. It would certainly be desirable for such an intricate notation to be simplified.

The book ends with eighty pages of tables giving the numerical values of certain actuarial functions according to various laws of mortality.

W. E. H. B.

Our Bookshelf.

Nutrition de la plante: utilisation des substances ternaires. Par Prof. M. Molliard. (*Encyclopédie Scientifique: Bibliothèque de Physiologie et de Pathologie végétales.*) Pp. 306. (Paris: Gaston Doin, 1923.) 15·40 francs.

IN this volume the author has aimed at presenting, as a concrete whole, much of the scattered information with regard to the ultimate utilisation of the non-nitrogenous compounds produced by plants in the course of their metabolism. Dealing in the first place with the digestion and migration of reserve materials, chiefly sugars, starches, and oils, attention is directed to the function of the various diastases, and to the mechanism of diastatic action. It is concluded that diastatic reactions represent merely a particular case of the ordinary catalytic phenomena, the apparent discrepancies being explained by the colloidal nature of the catalyser and the physical properties of the products resulting from the reaction. Respiration, with its attendant phenomena of oxidation, is discussed in some detail with special reference to the function and mode of action of the oxydases. Other oxidation processes are exemplified by fermentations induced by some of the lower fungi and bacteria, as in the production of acetic acid by various bacteria and oxalic and citric acids by certain Mucedineæ. The final chapters deal with fermentations which do not result in the fixation of oxygen, particularly alcoholic fermentation and intramolecular respiration, together with the production of such substances as lactic and butyric acid by bacteria in the presence of the appropriate sugars. The book thus provides a useful résumé of the aspect of plant nutrition with which it deals.

Matter, Life, Mind, and God: Five Lectures on Contemporary Tendencies of Thought. By Prof. R. F. Alfred Hoernlé. Pp. xiii + 215. (London: Methuen and Co., Ltd., 1923.) 6*s.* net.

THE five lectures in "Matter, Life, Mind, and God" present us with the main tendencies of philosophical thought in respect of the great problems of philosophy indicated by the title. Prof. Hoernlé's aim is to consider these questions synoptically, and he shows admirably how no one abstract point of view of a single science can be considered as having exhausted reality. His treatment of the relations of science, religion, and philosophy, of the tendency away from a materialistic outlook (he calls this chapter "The Revolt against 'Matter'"), of the order of Nature, of the nature and function of mind, and of religion and the meaning of "God," is fresh and stimulating. The book suffers from a certain diffuseness, which is perhaps inevitable considering the wide range of the tendencies of thought which are considered in it; and this fact is apt to mask the synoptic conclusions which the reader is expected to draw from it. There are excellent bibliographies appended to each chapter, with notes as to the relevancy of works cited to various positions stated in the text.

Memories of Travel. By Viscount Bryce. Pp. xiii + 300. (London: Macmillan and Co., Ltd., 1923.) 12*s.* 6*d.* net.

FROM many notes of travel, written in various parts of the world, these sketches have been selected for publication. They cover a wide range, Iceland, Poland, the Alps, Palestine, Siberia, North America, and the islands of the Pacific. Slight as most of the chapters are, they were well worth publication. Lord Bryce was a careful observer of Nature and had interests so wide and a taste in scenery so catholic that every land seems vivid before the reader's eye. His charm of style and ease of description make one overlook the occasional weakness in his geological explanations. The chapter on Iceland, written in 1872, gives a description of Icelandic scenery and peasant life that could scarcely be improved and yet it runs to less than fifty pages. Vivid pictures of Tahiti, of travel in the Altai mountains, or climbing in Europe are equally fresh and interesting. Even his "catalogue of the scenery of North America" is most attractive, although the whole continent is embraced in some two dozen pages. It is to be hoped that further sketches will be selected for publication from the wealth of material which Lord Bryce left. There is ample room among works of travel for these delightful sketches.

The Appearance of Mind. By James Clark M'Kerrow. Pp. xv + 120. (London: Longmans, Green and Co., 1923.) 6*s.* net.

THIS is a first book by a young author. It is a striking argument ably developed. It is almost a commonplace in philosophy to deny the reality, in the sense of substantial or causal unity, of the object of knowledge, and to reduce things to phenomena. Mr. M'Kerrow holds that the notion of mind is even more misleading and less justifiable. It must be desubjectified in a way which even Hume did not succeed in attaining. The immaterial principle which he would substitute for mind is "viable equilibrium." He denies that his theory is identical with behaviourism, which is equally anxious to disclaim mind, but he suggests that it may supply just what is wanting to behaviourism to make it work.

The Chemistry Tangle Unravelled: being Chemistry systematised on a New Plan based on the Works of Abegg, Kossel, and Langmuir. By Dr. Francis W. Gray. Pp. x + 148. (London: Longmans, Green and Co., 1923.) 6*s.* net.

THIS book is mainly an exposition of the work of Kossel. In spite of its title, it does not throw any new light on chemical problems, and the student would be well advised to read the original papers of Kossel, Lewis, and Langmuir rather than to attempt to absorb their theories in the less attractive form in which they are presented by Dr. Gray.

Letters to the Editor.

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

The Isotopes of Germanium.

USING the improved method of accelerated anode rays I have been successful in obtaining the mass-spectrum of germanium. The anode contained a fluorine compound made by the action of HF on a pure specimen of germanium oxide for which I am indebted to Prof. Dennis of Cornell University.

The effects are somewhat feeble, but satisfactory evidence of three isotopes has been obtained. Their mass-lines are at 70, 72, 74, and appear to be whole numbers though the accuracy of measurement is not so high as usual. The intensities are roughly in the proportion 2 : 4 : 5, which agrees reasonably well with the value 72·5 for the chemical atomic weight at present in use.

These values conform to the general rule connecting even atomic number with even atomic weight. It will be noticed that Ge^{70} is isobaric with the weakest and heaviest component of zinc discovered by Dempster, and Ge^{74} isobaric with the lightest and weakest isotopes of selenium announced in NATURE of November 18, 1922, p. 664.

F. W. ASTON.

Cavendish Laboratory,
Cambridge, May 23.

The Wave Theory and the Quantum Theory.

IN a letter published in NATURE on December 23, 1922, I put forward a theory of dispersion which attempted to begin the reconciliation of the quantum theory with the wave theory. I have received several letters criticising my hypothesis, and it seemed to me that it would be well to acknowledge the justice of the criticism. By a small change it is possible to meet the objection, but this change carries certain important implications. In my former letter, in order to be concise, I had to get as quickly as possible to the positive results, but here I wish to set out the train of thought from which the hypothesis started, and to indicate some of its consequences. It is perhaps well at once to say that in its present shape the hypothesis is in rather severe difficulties over one phenomenon, but nevertheless the argument leads to a good many criticisms of existing theories which may be of interest.

It must be taken as absolutely certain that both the electromagnetic theory and the quantum theory are valid in their respective fields, and equally certain that the two descriptions are incompatible. We can only conclude that they are parts of an overriding system, which would give rise to mathematical formulæ identical with those of the present theories. It is true that from the present theories predictions can be made which are verified; this does not confirm the physical pictures associated with those theories, but only shows that the limits of their validity have not been reached. Now although the developments of the quantum theory in the past ten years have been enormous, and though there is no sign of their ceasing, yet these developments have not tended in the very smallest degree towards closing the gap which separates it from the wave theory. For this reason it seemed to me that the only hope of finding a reconciliation must lie in some other direction, and that it would be best deliberately to give up thinking of details and to go back to fundamentals.

In starting to modify existing theories it is obviously best to change as little as possible, and therefore we have at once to choose whether it shall be the wave theory or the quantum theory which shall serve as basis. On this question there will be a great diversity of opinion, but to me it seems that the wave theory is undoubtedly to be preferred. The chief reason for this is that, so far as we know, the classical theory gives correctly the observed results in the interference of light, no matter how high the frequency or how feeble the intensity; so that even if we could find a new language in which to describe interference, it would be possible exactly to transform the mathematics which expressed it into the present language of waves. In other words, the wave equations imply an infinite number of degrees of freedom and it can make no difference by what name these degrees are called. The main objection to the electromagnetic theory is that it claims to present a *complete* system of mechanics, and it is this completeness that is its fault; but the wave theory is only a part of the electromagnetic theory, and we can get a large latitude for modification by retaining only this part and altering the part which describes the interaction of waves with matter.

In the quantum theory it must be conceded that, for such things as resonance potentials or the hydrogen spectrum, it is extraordinarily difficult to conceive of any alternative explanation; but, even allowing for the danger of being over-critical of an avowedly incomplete theory, it is not too much to say that from first to last the associated physical picture is in great difficulties. In the first place frequency, which plays such a leading part in the theory, is not at all the same thing as it is in mechanics, and is not susceptible of any clear definition. Then there is the difficulty that the quantum conditions determining the permissible Bohr orbits can only be explained physically by attributing to the electrons a knowledge of the future. Again there is the extreme formalism of the Correspondence Principle, a most powerful method of advance, but one which even by itself would force one to believe in the inadequacy of the quantum picture. A great part of the success of the theory of spectra has lain in the demonstration that the properties of the atom can be described in terms of whole numbers, but the dynamical concepts associated with these numbers are chiefly derived from analogy with the case of hydrogen, and could be reinterpreted in conformity with any new interpretation that was found for hydrogen. For all these reasons it is natural to suppose that the complete picture will resemble the classical theory much more closely than it will the quantum theory.

In my former letter I brought up the point that there is no reason to believe in an exact conservation of energy, but only in a statistical balance. The point is not at all new, but from much discussion of the subject I think there is no doubt that many physicists consider a breach of the law of conservation as a serious objection to any theory. If we are to believe at all in the wave theory it is much more reasonable to maintain the exact opposite. The photoelectric effect is an impossibility in conjunction with the wave theory if energy is exactly conserved, but if only a statistical balance is required, then it becomes nothing more than one unexplained problem among others. Again there exist rigorous proofs that no system of differential equations can give the observed law for the partition of energy among a large number of degrees of freedom; but these proofs make use of exact conservation, and fail if it is denied; so the denial makes it far more possible to believe in the continuity of Nature. In the course of various discussions it has been suggested to me that it would be more satisfactory to suppose that energy was exactly conserved, but could become latent. It is difficult to see what advantages such an idea can have; but, at any rate, there is an essential difference in it, for it would imply that the total apparent energy of an enclosed system will fluctuate about a *fixed* average value, whereas in the case of a statistical balance it may slowly wander away from the initial value and will exhibit no tendency to return to it. Of course the wave equations possess an energy integral, and so acceptance of the wave theory implies conservation of energy in free space; it is for interaction with matter that it need not hold.

The principal point which I wish here to make is that a mere acceptance of the wave theory implies certain important consequences, which must follow no matter what is the nature of the reaction between waves and matter—consequences which have perhaps not always been fully appreciated. The starting-point is that when a light wave acts on matter there is certainly a reaction on the light and that it is inconceivable that this should be anything but a spherical wave issuing from the matter. Now consider what happens when light is absorbed. Evidently the molecules must give out waves of such a type that the transmitted light is reduced in intensity, and the diminution can only arise through the interference pattern composed by the plane and the spherical waves round about the produced direction of the incident beam. Moreover, the reduction is only possible if *there is some phase relation between the incident and the emitted light.* Examined from any other direction there will be no interference and the matter will appear to emit light—in other words, there must certainly be a scattered wave. It can be shown without more specific hypothesis that its magnitude is related to the optical constants of the matter in much the same way as it is in the classical theory. To any one accustomed to thinking only in terms of the electromagnetic theory there will be nothing remarkable in all this, though it is worth noting how much more general it is than the electromagnetic theory; but I have never seen the point mentioned in connexion with the quantum theory, and it appears to me that this scattered wave, having a phase relation with the incident and determining the balance of energy, is one of the most essential features to be watched in any attempt to work out a quantum theory of absorption.

In my former letter a similar argument led to the dispersion formula. Dispersion is more or less adequately described by the classical theory, provided that the electrons are supposed to be retained with such forces that in a free vibration they would emit light of frequency corresponding to some spectrum line. On the other hand, this line can only be described in terms of the quantum theory by the difference between the energies of two stationary states. Now the most striking merit of the Bohr theory was that it gave a simple physical meaning to the "terms" of the spectrum line, and the meaning ought also to apply for refraction. For this reason I tried the idea that an atom could only give out a standard type of wave, intending it to be the same wave as in a free emission, and was much surprised to find how easily this led to the ordinary dispersion formula. In a private letter Prof. Bohr pointed out to me an objection which makes it impossible to maintain the hypothesis in this simple form, because if the standard wave were as large as is indicated by the quantum theory, it would not explain the refraction of very faint lights. He has since published the same criticism in *Zs. f. Ph.*, vol. 13, 3, p. 117. I had overlooked this important point, but after writing the letter I came across another result which suggested the need for modification. This was that the intensity of scattering of hard γ-rays would be proportional not to the intensity, but to the amplitude of the incident rays. This seemed a very improbable result, but not quite inconceivable in view of the well-known difficulties about the scattering of γ-rays. In the course of a visit which I paid to Montreal, Dr. J. A. Gray, of McGill University, who is familiar with such work, very kindly agreed to examine the question experimentally, and has since informed me that he has verified that the scattered intensity is proportional to the incident intensity.[1] In the meanwhile it was evident that a simple modification of the hypothesis would meet the difficulty, and it also meets Prof. Bohr's objection. It was before assumed that the scattered light depended on the product of two factors. One of these was the probability of excitation, proportional to the rate of change of the incident electric force; this I called $A_n(\delta E/\delta t)dt$. The other was the amplitude α_n of the standard wave. It is only necessary to alter the assumptions by taking $A_n dt$ as the probability and $\alpha_n(\delta E/\delta t)$ as the amplitude of the scattered wave for both objections to disappear. The excited wave is still characteristic of the atom in frequency and phase, but its amplitude is proportional to the incident wave. This is the form of the theory with which I have since been working. But the failure of the standard wave is a very severe blow to accepted ideas of the quantum theory. It is not possible to suppose that the atom goes right into its upper quantum state; but instead we are forced to believe that the atom, so to speak, knows what the upper state is like without going there, and the exact opposite of this is one of the greatest merits of the Bohr theory. We must now believe (and the same conclusion can be drawn from the views of Bohr in the paper already cited) that the two stationary states associated with a spectrum line have a much more intimate connexion than is suggested by the theory of emission, a connexion of which their dynamical formulation gives no hint; and once this is admitted it becomes very questionable exactly what the physical nature of the states may be, and how much further we may depend on the simple ideas hitherto in vogue.

The necessary abandonment of the standard wave destroyed the strongest argument for my hypothesis, as it could no longer unite the classical theory with the simple form of the quantum theory. Nevertheless it seemed well worth while to follow it up, for it explains interference while departing very widely from the difficulties in which the classical theory is involved. In the course of later work it has appeared that all the ordinary phenomena of optics are given quite satisfactorily, including dispersion, metallic reflection, optical activity, X-ray reflection, and scattering as exemplified in the light of the sky. The theory gives a straightforward interpretation of one of the two effects recently discovered by Clark and Duane (Proc. Nat. Acad., vol. 9, p. 126 and p. 131). For the "X-peak" I know of no explanation, but the other effect strongly suggests that white X-rays can excite the characteristic radiations of the atoms of a crystal *in phase.* In this instance I think my hypothesis has very distinct advantages over the classical theory, but it would be premature to discuss

[1] The test consisted in varying the distance of the source—changing its amount would not have done.

the matter here. What may be called second order scattering does not work very well on the hypothesis, but neither does it on the classical theory. Rather perversely the phenomenon which causes almost insuperable difficulty is the one which is most satisfactory on either the classical or the quantum theory, and that is the phenomenon of resonance radiation, as exhibited in Wood's work with mercury vapour. On my hypothesis the vapour ought to be excitable by light of wave-lengths different from its own, instead of requiring a very exact adjustment in the incident light, as it in fact does. It seems possible that a satisfactory modification of the hypothesis might result from a study of this failure.

In connexion with resonance radiation it is worth raising the question of whether the resonant light has a phase relation with the incident. In the quantum theory it is always assumed that it does not, but there does not seem to be much direct evidence. As pointed out above, there must be some light scattered in the process of absorption, and this light must have a phase relation, but it would depend on the phase difference whether this is the observed light or only a much weaker emission of the same frequency. I suppose the balance of evidence is rather against the phase relation; on that side there is the fact that one line of the spectrum can excite the emission of others, and there is some indication of the existence of a considerable latent period. On the other side any form of the wave theory requires that at least a part of the scattered wave should be in phase, and there is also some support, though not very strong, in Wood's recent discovery that the light is nearly completely polarised. Perhaps the work of Clark and Duane may also be invoked on this side.

As general conclusion the argument shows that the physical picture associated with the present quantum theory can be valid only over a very limited field, and that the more satisfactory parts of the electromagnetic theory can be taken over by a wave theory freed from many hampering restrictions.

C. G. DARWIN.

Institute of California,
Pasadena.

The so-called "Baccy-juice" in the Waters of the Thames Oyster-beds.

DURING May or June the waters over the oyster-beds at various places in the Thames estuary become periodically brown-coloured. This brown coloration is called "baccy-juice" by the local fishermen, who have connected with it such important observations on fisheries that its nature is worth recording. By the courtesy of Major A. Gardner and Mr. Louis French, I obtained on May 24 and May 28 townettings and living samples of the "baccy-juice" from off Whitstable and off West Mersea, and find, as surmised, that the brown coloration is due almost entirely to the presence of great numbers of the spherical colonies of the brown flagellate Phæocystis. It is well known that Phæocystis occurs periodically in the English Channel and in the North Sea, and it is not surprising that it should occur in a similar way in the Thames estuary. The occurrence of "baccy-juice" in the Thames estuary is not welcomed by the fishermen (excluding oyster fishermen), who say that it is useless trawling for fish in the locality of this material, and also state that a cold spell of a few days is sufficient to cause it to disappear; these apparently good practical observations are well worth recording.

The Phæocystis from both sides of the Thames estuary, it is interesting to note, were carrying on each colony two or three individuals of a species of Acineta, closely allied to if not identical with *Acineta tuberosa*, var. *fraiponti*, which is taking advantage of the floating Phæocystis to adopt a planktonic and semi-parasitic habit.

A brown coloration of the water over oyster-beds in the riverine portion of estuaries is also very common in summer and autumn, but in the rivers Yealm and Helford and in the Hamoaze estuary this colour is due almost entirely to various peridinians, which constitute a very large proportion of the diet of oysters at this time. In an estuary more open to the influence of the sea, where high salinities probably occur, as at Padstow, a brown coloration in autumn was found to be due to enormous quantities of a species of Chætoceras. In July 1922 the slight brown coloration of the water over the oyster-beds in the West Mersea creeks of the River Blackwater was due to a variety of diatoms, among which *Leptocylindrus danicus*,[1] Cleve, was the most common; but at the same time the diatom, *Nitzschia closterium*, was the dominant and almost the only floating form in those stagnant or semi-stagnant oyster-pits which had mud on the bottom.

J. H. ORTON.

Marine Biological Laboratory,
Plymouth, May 28.

The Relation of the Critical Constants and the True Specific Heat of Ferromagnetic Substances.

A MAGNET should have, like a fluid, three critical constants—a critical temperature, a critical intensity of magnetisation, and a critical field. The critical temperature and the critical intensity may be experimentally determined; the critical field is more difficult to find by experiment, but it may be calculated from the other two critical constants. When this is done for iron, cobalt, nickel, and magnetite it is found that the critical fields are very simply related to one another, being almost exactly in proportion to the numbers 1·0 (1·5), 2·0, and 3·0 respectively.

Further, these numbers are inversely as the true specific heats of these substances at their critical temperatures, and the product of the critical field and the true specific heat must therefore be a constant. For iron this constant is 0·0225, for cobalt 0·0230, and for nickel 0·0225; for magnetite it is 0·0691, but if this is divided by 3, the number of atoms of iron in the molecule, the result again is the number 0·0230.

The critical field is calculated as $\theta/8I_0$, where θ is the absolute critical temperature, and I_0 the maximum intensity of magnetisation; and hence the true specific heat multiplied by the ratio θ/I_0 is $0{\cdot}0225 \times 8$, that is, 0·18. Now this number is, to a close approximation, five times the energy per unit of temperature for one degree of freedom calculated from R, the gas constant, and the atomic weights of the ferromagnetic metals, and this points to the specific heat at the critical temperature as that corresponding to five degrees of freedom. As there are three degrees of freedom in the calculation of the specific heat at air temperature, there must be an acquisition of two degrees of freedom at the critical temperature, a conclusion which has been reached by a different method, and was the subject of a letter printed in NATURE of July 1, 1922 (vol. 110, p. 10).

The result stated above may be put in another way by saying that the thermal energy at the critical temperature and the maximum intensity of magnetisation of the ferromagnetic substances are proportional to one another.

[1] I am indebted to Dr. M. V. Lebour for this identification.

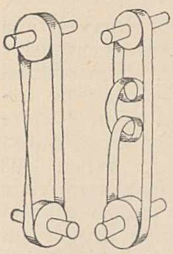
Some relation of this kind was surmised by Faraday, who wrote: "My impression has been that there was a certain temperature for each body (well known in the case of iron) beneath which it was magnetic, but above which it lost all power; and further, there was some relation between this *point* of temperature and the *intensity* of magnetic force which the body when reduced beneath it could acquire" (*Phil. Mag.*, 1836, vol. iii. p. 177).

J. R. ASHWORTH.

55 King Street South, Rochdale,
May 5.

A Puzzle Paper Band.

SOME thirty or forty years ago geometricians were much interested in the endless band of paper to which one half twist had been given before joining the ends. This gave the figure having only one surface and one edge. At that time those who studied this figure were so obsessed with the consequence of cutting down the middle line of such a band or of a band with two or more half twists that I believe no one noticed the result which I wish now to describe. It is the doubling up in a proper manner of an endless band to which four half twists have been given so as to produce the endless band first described but of double thickness. The first band is shown at A, as an endless belt connecting two crossed shafts for which, as is well known, it is exactly fitted. B shows the band with the four half twists all on one side in the form of two complete loops, and to be uniform with the other it is shown as an open band connecting two parallel shafts. The only object of putting in the shafts and pulleys is to assist the perspective. They are not wanted in making the experiment. Now if B, which appears sufficiently uncompromising, is folded up properly it becomes A but of double thickness.



A B

I used this doubled A for a time as a record sheet for my recording calorimeter, for, having a head-room to work in of four feet and a movement of paper of six inches a day, I was able in this way to obtain a continuous record for 32 days on one side of the paper only. This is superseded now by a more convenient arrangement.

It may be worth while to add that while lying awake one night I visualised A in two thicknesses and saw it to be what I wanted, and the next day I found it all right. What I did not visualise was the puzzle that it is to fold up B into an A of double thickness, and that it makes a first-class parlour puzzle game. It has this further advantage that a number may be made, some with right-hand and some with left-hand twists, so that any preliminary success gained on one may make the other seem the more difficult. The band should be not less than 50 times as long as it is wide.

Of the four half twists two are easily seen in the finished double thickness band, for each thickness has one half twist; it is amusing to find out where the other two have gone.

C. V. BOYS.

The Viscosity of Liquids.

IN NATURE for May 5, p. 600, Prof. C. V. Raman writes: "I have suggested that the viscosity of liquids and its variation with temperature may be explained on the hypothesis that the liquid state of aggregation is composite in character; that is, is composed in part of molecules 'rigidly' attached to each other as in a solid, and in part of molecules which are relatively mobile as in the gaseous state (NATURE, April 21, p. 532)."

The above hypothesis was suggested by me in a paper which appeared in the *Phil. Mag.* for Feb. 1888, p. 156. In solids the atoms or molecules, in normal conditions, are, in the majority of instances, adhering to each other, and if, owing to vibratory movements within the mass, the adhesion should be broken anywhere, the *same bond* is quickly restored if the mass be only moderately strained. If, however, the mass should be in a state of considerable strain, broken bonds may make new attachments, and the solid be permanently deformed. In the case of liquids, although the majority of the molecules are bonded by chemical forces, a number, depending upon the temperature, etc., are continually breaking bond, even in the absence of strain, but, instead of again remaking the original bonds, they may form *fresh bonds*. In the paper already quoted, p. 160, I remark: "Gravity may, therefore, give rise to a slow but continuous change of form in an elastic substance in the interior of which liquefaction and resolidification are constantly going on." The theory, particularly as regards ice, was afterwards developed in some detail, and I should like to invite attention to a paper on "The Viscosity of Ice," Proc. Roy. Soc. A, vol. 81, 1908, p. 250.

Irving Langmuir (Jour. Amer. Chem. Soc., vol. xxxix., Sept. 1917, p. 1858) also advances the same idea. He remarks: "The mobility of a liquid is thus due to a shifting of the relative positions of atoms which are all chemically combined with each other."

R. M. DEELEY.

Tintagil, Kew Gardens Road, Kew, Surrey,
May 14.

Perseid Meteors in July 1592.

IN NATURE of November 18, 1922 (vol. 110, p. 667), there appeared a letter from Mr. H. Beveridge, directing attention to a statement by Abūl Fazl that "on the 27th day of Tir O.S., which might correspond to about July 28, 1592, three hundred little stars or pieces of stars (*sitāracha*) were seen traversing the heavens from west to east." The date, Tir 27, belongs to the Târîkh-i Ilâhî, or Divine Era, which was used by Abūl Fazl, and must not be confounded with other calendars in which the same month names occur.

In a study assisted by Mr. Beveridge's courtesy I have examined a large number of dates belonging to this era, and I find that each year was made to begin at the sunset following the vernal equinox, and, so far as the dates can be tested by the days of the week or by an astronomical phenomenon, each month would appear to have been made to begin at the sunset following the entrance of the sun into a sign of the zodiac. There is one instance, however, where a month is made to begin one day earlier than it should according to this rule. According to this rule Tir 27 should begin at the twenty-seventh sunset after the summer solstice, which in the year 1592 would be on July 7 of the Julian calendar or July 17 of the Gregorian calendar, and I infer that the meteors were observed on the night of July 17-18 of the Gregorian calendar. There is no reason to suspect an error of more than one day in this date. In his translation of Abūl Fazl's Akbarnāma Mr. Beveridge identified Tir 24 of that year with July 4 of the Julian calendar, and I take it that July 28 in his letter to NATURE was a *lapsus calami*.

In the *Observatory* for May 1923, p. 169, Mr. W. F.

Denning examines the dates of abundant showers of Perseids and finds that a large proportion of them can be satisfied by a period of 11·75 years. This period would give an abundant shower for the year 1592, and Mr. Denning has included that year, apparently on Mr. Beveridge's authority, in the list of years of observed maxima. A list of Perseid showers, or at least of showers at the time of year when Perseids are expected, is to be found in Arago, "Astronomie populaire," iv. p. 296-8, and is extracted from Biot's "Catalogue général des étoiles filantes . . . observés en Chine," published in *Mémoires présentés à l'Academie, sciences math. et phys.*, x., p. 129, etc. To these Chinese observations it is possible to add one from Matthew Paris of the date 1243 July 26. The complete series then becomes: 714 July 15, 784 July 10, 830 July 22, 833 July 23, 835 July 22, 841 July 21, 865 Aug. 1, 924 July 21-23, 925 July 22, 23, 926 July 22, 933 July 20-25, 1243 July 26, 1451 July 27, all Julian dates.

An analysis of the dates of the medieval observations shows that the date of maximum intensity of the Perseid shower has not shifted its position in the sidereal year since the year 830 at latest. The date corresponds to a solar longitude of 138° reduced to the equinox of 1900. A few of the showers recorded in history fall a little before or after that date, and in two instances (784 and 865) the difference is as much as ten days on either side of the normal maximum. In 1592, on the other hand, the recorded shower falls nineteen days earlier than the normal maximum, and this raises a doubt whether it was really a Perseid shower at all or some otherwise unknown shower which happened to fall in a year when an abundant Perseid shower was due. J. K. FOTHERINGHAM.

University Observatory, Oxford,
May 21.

The Measurement of Overvoltage.

IN general, the term overvoltage refers to the difference between the potential required to discharge an ion at a particular electrode and the calculated reversible value, in the same electrolyte. Strictly speaking, therefore, overvoltage only exists while the current is flowing, and hence measurements should be made under these conditions. Some workers, however, state that the "transfer resistance" of a gas film at the electrode causes the measured potential to be in excess of the true value; consequently, an alternative method has been adopted in which a rotating commutator rapidly interrupts the polarising current and connects the experimental electrode with the potentiometer system. In this way disturbing influences due to transfer resistance are said to be eliminated, since the potential of the electrode is measured when the current is not flowing. This method gives lower results than the direct method for the following reasons: (1) When the polarising circuit is broken, an extremely rapid fall of potential occurs, which is appreciable even in the small interval that elapses between the periods when current flows; (2) since the current only flows intermittently through the experimental cell, current density and time effects are not comparable with those obtained when the current flows continuously; (3) the continual make and break of the circuit by the commutator sets up alternating induced currents, and it is well known that electrical discharges of such a nature tend to lower the potential of a polarised electrode.

In some recent work, hitherto unpublished, the magnitude of the effects due to these induced currents has been investigated. The lowering of potential was found to depend upon the particular electrode examined, and was usually of the order of 0·3 volt, and in some cases as much as 0·5 volt. The value of the induced current, and consequently its effect on the potential, will depend on the frequency of the intermittent current, and upon the resistance and self-inductance of the circuit; but it seems fairly certain that the lowering of potential, due to induced currents in the commutator method for measuring overvoltage, is considerable.

In order to eliminate as many sources of error as possible, the following method for the measurement of overvoltage is being tested. The commutator method is being used, but a "choking coil" of high self-inductance is placed in the circuit in order to reduce the induced current to a negligible amount. Further, instead of the polarising and potentiometer circuits being made for equal intervals of time, the latter will only be complete for about 10° in each revolution. Thus for about 97 per cent. of the time the polarising current will flow through the cell, and, if the commutator revolves 3000 times per minute, only 0·0007 seconds will elapse between opening and closing the current circuit. To ascertain the magnitude of the fall of potential during this period, further experiments will be made, either by varying the speed of the commutator, or by increasing the period per revolution in which the experimental electrode is connected with the potentiometer system. By extrapolation, it should be possible to determine the potential of the electrode at the instant of breaking the current, and the results compared with those obtained while current is still flowing, in order to determine the effect of the so-called "transfer resistance." S. GLASSTONE.

University College, Exeter,
May 22.

A New Phototropic Compound of Mercury.

IN an attempt to prepare the phototropic compound, dimercuric-diiodo-disulphide, described by Dr. Ray (Jour. Chem. Soc. 1917, T, 101-109), we accidentally discovered a new phototropic mercury compound of the formula $Hg\langle^{HS}_{CNS}$ through a mistake of the laboratory attendant in supplying us with potassium nitrate in the place of the nitrite. The compound is prepared by the interaction of a mercuric salt with ammonium sulphocyanide and thio-urea in a solution of acetic acid in the presence of an oxidising agent. The compound is also prepared by the action of hydrogen sulphide on mercuric sulphocyanide. This gives us a clue to the constitution of the yellow mercuric compound.

The compound is very phototropic, inasmuch as it is effected by strong sunlight in less than 1/60th of a second and by diffused daylight in a few seconds. It appears, therefore, to be the most phototropic compound as yet known. In researches on this compound we have prepared a red variety of mercuric sulphide by precipitation methods. Again, by the decomposition of the yellow mercuric compound, we have prepared a yellow variety of mercuric sulphide which shows interesting thermotropic properties. By the action of free iodine on the new phototropic compound, an iodine compound of mercury which is also phototropic has been prepared. Further work is in progress. Y. VENKATARAMAIAH.
BH. S. V. RAGHAVA RAO.

Research Laboratories, Maharaja's College,
Vizianagram, May 9.

Ancient Egyptian Chronology.

By Dr. H. R. HALL.

WHEN one is told that Tutankhamen, the Egyptian king, the discovery of whose tomb, followed by the tragedy of Lord Carnarvon's death, has aroused such widespread interest in ancient Egypt, reigned roughly between the years 1360 and 1350 B.C., it is naturally asked by many how this is known with such certainty? The Egyptians had no regular era. They merely spoke of such-and-such a year of King X. The Assyrian, however, possessed a continuous era, of which each year was noted by the name of an eponymous official. The definite fixing of this Assyrian era has been due to the help of astronomy. In a certain eponymy of the eighth century B.C., an eclipse of the sun is recorded as having taken place in the month Sivan (May-June). This has been reckoned astronomically to have taken place in 763 B.C. All other evidence of the kind fits in with and confirms this: the eponym-dates are certain to the actual year so far back as 893 B.C., when the later Assyrian series began, and are also now certain to within a few years at a much earlier period. So far back as the ninth century, at least, then, we can fix Egyptian dates with the aid of Assyrian synchronisms, and we find that Shishak I., the conqueror of Jerusalem, must have reigned about 930 B.C., which is not so different from the old traditional biblical date of 975 B.C.

Besides having no era, the Egyptians took no notice of eclipses. They did, however, possess an "epoch" which was based on astronomical observation: the "Sothic cycle." At an early period, apparently in the year 4241 or 4238 B.C., the Egyptian calendar was fixed to begin with the first day of the first month on the day of the heliacal rising of Sothis or Sirius. The year consisted of 360 ordinary days + 5 epagomenal. The necessity of intercalating a day every fourth year was not noticed. Hence, as time went on, the months lost all relation to the seasons, and the heliacal rising of Sirius would not correspond again with the first day of the year until a whole cycle of 1460 years had been completed. This cycle was recorded, but only used for calendrical purposes, never for dating events.

We know from classical sources that a new "æon" or cycle began in A.D. 139 or 143. The Alexandrian mathematician, Theon, called the beginning of the preceding cycle, which began in 1321 or 1317 B.C., the "era of Menophres." Now we know from synchronisms with Babylonian and Assyrian history, as well as from dead reckoning of the length of reigns, checked by the statements of Manetho (the Egyptian historiographer who lived in the third century B.C.), that roughly about 1321–1317 B.C. must have fallen the short period between the Egyptian kings Harmais (Harmhab) and Seti I., the end of the XVIIIth and the beginning of the XIXth Dynasty of Manetho; and between them reigned Rameses I., whose second name was Menpehre. Evidently he is Menophres, and the beginning of the era and the date of either 1321 or 1317 B.C. must have fallen in his reign. With this conclusion all the other evidence agrees.

Reckoning back from this date, we find that the dates of certain new-year festivals that are recorded on certain days of the month in certain years in the reigns of Thutmases (Tethmosis or Thothmes) III., and Amenhatpe (Amenophis) I., predecessors of Menophres, can be fixed to the years 1474 or 1470, and 1550 or 1546 B.C. The date for Thutmases III. is confirmed by the identification of two new-moon festivals recorded on certain days of the month in two stated years of his reign as those of May 15, 1479, and February 23, 1477 B.C. Our very full knowledge of the history of this time (the XVIIIth Dynasty) enables us to say definitely that these dates correspond to what a dead reckoning of the kings' reigns back from Menophres would demand. Also they fit in absolutely with the dates, based ultimately on the eponym-lists, demanded for Babylonian and Assyrian history at this time, when synchronisms with Egypt were frequent. Computing further back from the reign of Amenhatpe I. we find that I'ahmases (A'ahmes or Amosis) I., his predecessor, and the founder of the dynasty, must have ascended the throne within a few years either way of 1580 B.C.

So we know that Tutankhamen reigned about 1360–1350 B.C. He preceded Menophres by about thirty-five years, most of which was occupied by the reign of Harmais or Harmhab. The heretical king Akhnaten, the monotheistic worshipper of the god of the sun's disk, of whom there has been so much talk lately, and his father the great Amenhatpe or Amenophis III (Nibmare, the Mimmuriya of the contemporary Babylonians and Memnon of later Greek legend) will have reigned *circa* 1410–1360 B.C., the date also demanded by the synchronisms with Babylonia.

I have implied that no Egyptian dates earlier than 1580 B.C. are so certain as these. Of course there are the exceptions of the era-dates of 2781 (2778) and 4241 (4238) B.C. But we do not know what kings were reigning at these dates. Amosis, I imply, is the first king of whose date we can be certain; but this view is not universally held by Egyptologists. Some would go further back, to at least 2000 B.C. for certain dates, which are again deduced from the Sothic reckoning, on the following grounds.

In a papyrus of the XIIth Dynasty it is stated that Sothis rose heliacally on a certain day of a certain month in the seventh year of King Senusret III. German investigators have computed this date at 1882 (1878) or 1876 (1872) B.C.; but from the same data a British computer, Mr. Nicklin, has arrived at the date 1945 B.C. There is, therefore, evidently some room for doubt in the matter.

The German date is, however, generally received, and the XIIth Dynasty therefore currently ascribed to the period 2000–1788 B.C. But, apart from the fact of Mr. Nicklin's varying computation this date has seemed to several, including myself, to be open to serious objection, because it does not allow sufficient time for the XIIIth Dynasty and the period of the Hyksos kings. We have an Egyptian record of the kings, the Turin Papyrus, which gives a long list of the monarchs of this period, though without dates. Manetho, the Ptolemaic historiographer (or his commentators) assigns a lengthy period of time to this age. Yet the evidence from Crete is in favour of a short period, and would not disagree with the German dates. That of Egyptian archæology and art is also in favour of the shorter dates, yet scarcely for so short a period as a bare two hundred years. We have, too, so many contemporary records of kings of this time (apart from the evidence of the Turin Papyrus) that we cannot suppose that only two hundred years elapsed between the end of the XIIth and the beginning of the XVIIIth Dynasty. The Hyksos period alone can, one would think, scarcely have occupied less than two centuries.

So impressed is Prof. Flinders Petrie by these arguments (and others) that he boldly supposes that we must put the XIIth Dynasty back a whole Sothic period in time, and make Senusret III. reign about 3300 instead of about 1900 B.C. He has not been followed in this cutting of the Gordian knot, for few will believe that 1600 years can have elapsed between the two great dynasties, which on the ancient monumental lists of kings at Abydos and Sakkarah are immediately coterminous, the Hyksos and their predecessors being regarded either as usurpers or of no account. Prof. Capart is the only Egyptologist who seems inclined to go somewhat in the direction of supporting Prof. Petrie, but he must do so at the expense of abandoning the astronomical calculation, which Prof. Petrie accepts.

Personally, being unable to believe either that so few as 200 or so many as 1600 years separated the two dynasties, I can only suspend judgment until the astronomers have examined the question and the evidence anew and have recalculated the date indicated by the observation in Senusret's reign. Until then I can only suppose that some mistake either in ancient observation or modern calculation has occurred, and adopt provisionally the very round date of *circa* 2000 B.C. for the end of the XIIth Dynasty, which would satisfy most historical, archæological, and artistic demands.

This date would give the Middle Kingdom (XIth-XVIth Dynasty) the date *circa* 2350–2000 B.C. We know the lengths of the reigns of the kings of the XIIth Dynasty accurately from contemporary monuments, and Manetho combined with the monuments gives us an adequate idea of the XIth.

Now the Turin Papyrus becomes important. Its regnal years for the Old Kingdom (Dyns. I.–VII.) are often useful, in conjunction with Manetho and the monuments, and it gives the definite sum-total of the reigns of this period as 955 years. Allowing about 150 or 200 years for the IXth and Xth Dynasties (so far as they were not contemporary with the VIIIth and XIth) and for the period of interregnum in art and civilisation which certainly elapsed between the VIth and the XIth, we can roughly date the Old Kingdom to the round date *circa* 3500–2500 B.C. The three conquerors of the North, the Scorpion, Narmerza, and 'Ahai, who seem to have become conflate in later Egyptian legend as Meni or Menes, the first king of all Egypt and founder of the Ist Dynasty, will then have reigned about 3600 or 3500 B.C.

This date is about two centuries earlier than that maintained by the Germans, who are followed by Prof. Breasted. Prof. Petrie, of course, in accordance with his theory, goes much further back, returning to the remote date of more than 5000 B.C. which used to be credited twenty or thirty years ago. Capart moves in the same direction, too far in my opinion, and relying somewhat on an interpretation of the evidence of the fragments of the Palermo Stone (an ancient contemporary monumental chronicle of the time of the Vth Dynasty) put forward by Borchardt, which has been shown to be misconceived and untrustworthy by Prof. Peet.

The predynastic period, when there existed two independent kingdoms, if not three, in Egypt, which had arisen out of neolithic primitiveness, will then date to any length of time before 3500 B.C. that one may be inclined to credit. The institution of the fixed calendar in 4241 or 4238 B.C. will have been the first important sign of civilisation in Egypt.

Such, explained as succinctly as possible consistently with intelligibility, is the evidence on the subject of ancient Egyptian chronology. If the astronomers will turn their attention to the Kahun date and recompute it, and also tell us whether any ancient mistake is possible and of what kind, we shall all be better able to make up our minds on the subject of the dates before 1580 B.C.

That there is room for a recomputation is shown by the divergence of the calculations of Mr. Nicklin and of the Germans. That doubts of the necessary validity of all astronomical calculations of this kind are not altogether mistaken seems to be shown by the fact that the astronomical fixation of certain early Mesopotamian dates by Kugler, which has been accepted for several years past, is now discredited by many Assyriologists on the authority of the newly-discovered Assyrian king-lists and on account of the fact that Kugler's calculations, I understand, place the harvest season at an impossible time of the year. These doubters would bring the epoch of Hammurabi down again to nearly the date originally advocated by the late Prof. King before he accepted Kugler's results.

The 800th Anniversary of the Foundation of St. Bartholomew's Hospital.

IN the long history of St. Bartholomew's Hospital, now extending over eight hundred years, during which the gates have never been closed or the wards entirely empty, many men have served the Charity well and faithfully. The exacting nature of the duties required of those attending upon the sick do not leave much time for speculative science, but the staff of the hospital has always been foremost in advancing the art of physic. The hospital was founded in 1123; and the celebration of its eight hundredth anniversary is being held this week. It was founded upon a religious basis and was placed in charge of a master, eight brethren and four sisters of the Augustinian Order. They had no science, but the scanty records of the treatment adopted shows that common sense prevailed and the experience gained was sufficient to build up a great tradition of practice and nursing.

The religious foundation lasted uninterruptedly for four hundred years until the Reformation led to a reconstruction. The enlightened policy of the citizens of London prevented spoliation and wholesale destruction, so that the Charity as it exists to-day still retains some of its original archaic characteristics. A succession of great surgeons—Vicary, Gale, Clowes, and Woodall—held office in the hospital under the later Tudor sovereigns. They were men who had gained their experience in the foreign wars and had served so far afield as Poland and Russia. Rough, practical surgeons, they concerned themselves with the sick and hurt and in an abortive attempt to raise their own professional status. Of science they knew nothing. It was slightly better, perhaps, on the medical side. Dr. Timothy Bright did some service when he invented his system of shorthand, but the discoveries of William Gilbert in magnetism seem to have been entirely unknown to them, although as members of the same profession and of the same college, living together in a small town, they must have been constantly in association with him. The governors of the hospital would indeed have done themselves great honour had they chosen him as their first physician under the new foundation instead of electing one who was afterwards hanged, drawn, and quartered for conspiring to poison Elizabeth.

The real scientific history of the hospital begins with William Harvey, appointed physician in 1609, who announced his discovery of the circulation of the blood in the Lumleian lectures at the College of Physicians in 1616. The discovery revolutionised the practice of medicine and made possible an experimental physiology. The very simplicity of the proofs were a stumbling-block to his contemporaries, but the teaching was eagerly accepted by the younger generation, those founders of the Royal Society who formed so wonderful a band at Oxford and in London just after the Restoration.

When Harvey died, the mantle of science in the hospital fell sometimes on the medical and sometimes on the surgical side of the house. Percivall Pott began to teach surgery systematically, and his lectures were attended by John Hunter, the founder of scientific surgery in England. The pupils of Pott followed each other in a long succession as surgeons to the hospital and *quasi cursores* handed on the Hunterian teaching to our own day. Earle and Abernethy, Lawrence, Savory, and Butlin bridged the interval between the death of Hunter and the dawn of Lister. But, as in the time of Harvey, the older teaching had become so ingrained in the school that it was found difficult to accept the doctrine of the germ theory of disease and the revelations of antiseptic surgery. It was not until a new generation came into its own that men like C. B. Lockwood entered whole-heartedly into the promised land of Listerism, and Klein, Kanthack, and Andrewes advanced the great science of bacteriology.

Until 1836 the teaching of chemistry was in the hands of the physicians to the hospital, but from that time onwards it became specialised and the school was fortunate in obtaining a regular succession of first-rate teachers; Brand, Stenhouse, Frankland, Abel, Odling, Russell, and Chattaway followed each other, the students were well taught, and some opportunities were afforded for original work. In like manner, Sir Lauder Brunton, before he became physician to the hospital, was a pioneer in experimental pharmacology, and in that branch of knowledge which has since developed into bio-chemistry. Between 1882 and 1912 Steavenson and Lewis Jones by their work at the hospital raised medical electricity from a scientific empiricism to its position as a recognised branch of medicine. Lewis Jones, indeed, in his all too short life fairly earned the title of "the Father of Medical Electricity."

A great hospital leads to advances in many departments of science. New problems are constantly presented; the permutations and combinations arising in the complex structure of the human body are endless and the chemist and physicist are often able to give material help in placing medicine upon a firm basis of fact.

The Complete Gasification of Coal.

By Dr. J. S. G. THOMAS.

IT is well known that the percentage thermal efficiency of gas production from coal can be increased by gasifying the coke resulting from the high temperature carbonising process, and various processes and plants for effecting this conversion have long been available. Shortage of fuel supplies during the years of the War, and afterwards, resulted in the Board of Trade issuing instructions to gas companies to "stretch" their supplies of gas. The "stretching" process intended was to consist of a reduction of calorific power of the gas supply, accomplished by dilution of straight coal gas with either blue or carburetted water gas. The attention of the industry in all countries was, at the time, naturally directed towards increasing the efficiency of production of water gas and its efficient utilisation admixed with coal gas in a towns' gas supply. In England considerable work on these lines was done by George Helps, the "big noise" of Nuneaton.

Much publicity has recently been given to a plant designed by C. B. Tully, and operated at Bedford, for the complete gasification of coal. Altogether, since 1919, about two hundred such plants have been erected in this country, the largest being installed at Halifax, which is capable of producing about 7000 therms per day. The installation at Bedford comprises two sets, each capable of producing about 2500 therms per twenty-four hours. The average percentage composition of the gas is approximately CO_2, 5; N_2, 5; O_2, 0·5; CO, 36; H_2, 45; CH_4, 8; C_nH_m, 0·5, and the calorific power is about 350 B.Th.U. per cubic foot. Bedford is supplied with a mixture of straight coal gas with about 51 per cent. of this gas, the resulting calorific power being about 460 B.Th.U. per cubic foot. Manufacturing costs in the case of the Tully plant are stated to amount to about 2·74*d*. per therm and the capital manufacturing charges to about 0·08*d*. per therm. The desirability or otherwise of the manufacture and distribution of this gas in any definite case must be determined by a variety of factors, among others by the size of the undertaking, local conditions as regards supplies of raw coal, characteristics of the demand for gas, storage capacity, and size of the distributing system. Increased costs must be incurred in the distribution of the gas compared with those incurred in the case of straight coal gas.

On one matter to which public attention has recently been directed we would remark that the possibility of converting the comparatively large percentage of carbon monoxide in water gas into carbon dioxide or methane is by no means a novel proposition either from the scientific or industrial point of view. Sabatier and his co-workers showed, many years ago, that in the presence of nickel, cobalt, or palladium, carbon monoxide and hydrogen at 230-400° C. react to form methane and water, thus : $CO + 3H_2 = CH_4 + H_2O$. This hydrogenation is subject to the important objection from the technical point of view that while hydrogen must be present in excess, an equal volume of hydrogen must be added to water gas to provide the mixture theoretically necessary. This hydrogen can be derived from water gas, and the net result is that the yield of methane is only about 15 per cent. of the total water gas employed. Sabatier pointed out that by passing water gas over nickel at 400-500° C. the following reaction occurred; $3CO + 3H_2 = CH_4 + H_2O + C + CO_2$. The carbon deposited on the catalyst may, at the same temperature, be caused to react with steam to form a mixture of hydrogen, methane, and carbon dioxide, whereby the catalyst is regenerated for use in the first phase of the process. Sabatier further suggested that both phases might be combined by passing water-gas and steam over a nickel catalyst at 400-500° C., when the following reaction occurs: $5CO + 5H_2 + H_2O = 2CH_4 + 2H_2 + 3CO_2$.

These various reactions are summarised in a recent paper by Drs. E. F. Armstrong and T. P. Hilditch, read before the Royal Society (see NATURE, February 3, p. 168), in which they direct attention to a reaction between carbon monoxide and hydrogen which has hitherto apparently escaped notice. They find that the action between equal volumes of carbon monoxide and hydrogen in the presence of nickel or a similar catalyst at temperatures below 300° is in the main represented by $2CO + 2H_2 = CO_2 + CH_4$. It will be noticed that the gases carbon monoxide and hydrogen participate in the reaction very approximately in the relative proportions in which they are present in blue water gas, (43 per cent. CO, 48 per cent. H_2). The reaction, though never complete, proceeds to a very considerable extent, and the authors consider the process may be of value in gas practice as the proportion of methane is 25 per cent. of the water gas decomposed, whereas by any of the other processes referred to the maximum possible yield is only 20 per cent.

The idea of the technical utilisation of the first reaction referred to above for the production of methane, and the application of the reversible reaction $CO + H_2O = CO_2 + H_2$ for the production of hydrogen has recently been revived in connexion with the Tully plants. It must be realised that little if any actual large-scale operations of this nature have hitherto been carried out. Considerable experience is necessary for the successful operation of catalytic plants operated at relatively high temperatures and dealing with the huge volume constituting a day's make of towns' gas in the case of even one of the smaller gas companies. It is contemplated that the plant required would be of the same nature as that designed for the catalytic purification of gas from sulphur compounds which is in successful operation in the works of the South Metropolitan Gas Company. Operating charges would possibly amount to about ¼*d.* per therm. It is questionable whether it would be technically feasible to remove the carbon dioxide produced. A suitable catalyst has been prepared, and small-scale operations in a plant capable of treating 200 cubic feet of gas per hour have been carried out. Large-scale operations constitute a much more difficult proposition.

Obituary.

MR. F. W. HARMER.

BY the death on April 24 of Mr. Frederic William Harmer, within a few days of the completion of his eighty-eighth year, the county of Norfolk loses one of its most distinguished sons and East Anglia the penultimate survivor of a band of amateur and professional geologists to whom science is under deep obligations, not merely for the elucidation of local problems, but for the establishment of principles and of methods of research of European or even wider application.

Mr. Harmer, descended from a stock the most ancient in Norfolk, was early imbued with a love of science, especially of geology, and the fortunate chance of a meeting in 1864 with Searles V. Wood the younger directed his enthusiasm and energy along lines of research that, with one significant break, he followed to the end of his long and useful life. The two friends embarked upon the study of the records of the Ice Age, and, in pursuance of Wood's conviction that accurate mapping of the glacial deposits was essential to the decipherment of their story, the task—never before attempted—was undertaken, and in the course of a few years an area of 2000 square miles was mapped on the scale of one inch to the mile. Harmer's share was the county of Norfolk and the northern parts of Suffolk.

Wood told the present writer that the young officers of the Geological Survey with whom he was often in conflict ought to be grateful to him and his friend because their demonstration of the practicability of mapping drift deposits had compelled the Survey to increase its staff. Copies of the map, claimed by its authors to be the first of its kind ever produced, have been deposited in the library of the Geological Society and in the Museums at Norwich and Ipswich, and a lithographed reduction of the eastern portion was appended by Wood to one of the supplements to his father's great monograph of the Crag Mollusca.

The period of his association with Wood, of whom Mr. Harmer always spoke with touching reverence and affection, was brought to a premature close by the complete breakdown of Wood's health ending with his death in the early 'eighties. The loss of his friend and master acted as an effective damper upon Mr. Harmer's geological activities, and for more than a decade he threw his energies into business and the multifarious duties of municipal life.

The meeting of the British Association at Ipswich in 1895 was marked by the reappearance of Mr. Harmer, to the great surprise of a generation that had come to regard his work as finished. He presented two important papers upon the Coralline and Red Crags, which were received with great interest and attention by newcomers in the field of Pliocene geology and also by distinguished workers from France and Belgium present at the meeting.

From this time until the end of his life Mr. Harmer's interest and activity never flagged. He again took to the field and contributed many important papers to the Geological Society and other bodies. In Pliocene geology his achievements were many and valuable. The discovery of a deposit of Red Crag at Little Oakley, which yielded to his minute and pertinacious investigation a fauna of unparalleled richness, led him to a general review of the Pliocene geology of East Anglia, giving definiteness to the opinion long held by workers in that field that the deposits of Red Crag age marked successive stages in the withdrawal of the North Sea from south to north.

A discussion of the fragmentary Upper Tertiary patches of Lenham gave occasion for the correlation of the British Pliocenes with those of Belgium and Holland. His achievements in this field of study have the enthusiastic recognition of the geologists of Holland, Belgium, and France.

The remarkable contrast presented by the contemporary Pliocene deposits of the two sides of the North Sea in regard to the abundance of shells led to investigations of great moment. Premising that shells are cast up in profusion on the Dutch coast by the prevalence of onshore winds, Mr. Harmer showed that in Pliocene times the western shores received the shelly beaches. He proceeded from this to an elaborate discussion of the meteorology of the Pliocene and Glacial Periods, the first attempt by any man of science to apply the methods and results of modern meteorology to the solution of geological problems. This pioneer work has been followed up by many writers, notably in the recent book "The Evolution of Climate" by Mr. C. E. P. Brooks, to whom Harmer's work was apparently unknown.

The many additions to the Molluscan fauna of the Upper Tertiaries rendered necessary the resumption of the work of description interrupted by the death of the elder Searles Wood. Mr. Harmer undertook the task, and it is gratifying to know that shortly before the accident by which his death was accelerated he had revised the final proofs of the last of a series of supplements to the monograph on the Crag Mollusca published by the Palæontographical Society.

The great value of Mr. Harmer's work was recognised by his geological brethren; from the Geological Society he received the Murchison medal; he was elected successively Membre Associé Étranger and Membre Honoraire of the Belgian Geological Society; and the University of Cambridge conferred upon him the honorary degree of M.A.

Two of Mr. Harmer's sons adopted a scientific career, in which they have attained very high distinction; the elder, Sir Sidney F. Harmer, is well known as the director of the Natural History Department of the British Museum; the other, Mr. William Douglas Harmer, called at a very early age to the position of warden of St. Bartholomew's Hospital—always regarded as a presage of future distinction—is now the senior surgeon in the throat department of the hospital.

PERCY F. KENDALL.

MR. M. DE C. S. SALTER.

THE death on May 21, after a short illness, of Mr. Mortyn de Carle Sowerby Salter, at the early age of forty-two, removes from the scientific world an extremely able worker just at the moment when the mastery he had attained in his special field of study had brought him in sight of important achievements. The son of Mr. M. J. Salter, he was educated at Bancroft's school, and passed directly, at the age of sixteen years, to an assistantship in the British Rainfall Organisation under its founder Mr. G. J. Symons. Here he developed an aptitude for statistics and a patience with detailed routine which enabled him later to grasp the scientific principles underlying the distribution of rain and develop an enthusiasm for research combined with sagacity in the practical application of his knowledge.

Mr. Salter became my chief assistant at Camden Square in 1907, and from 1912 onwards relieved me of the whole responsibility for the accuracy of the annual rainfall tables in "British Rainfall." In 1914 he was appointed assistant-director and in 1918 joint-director of the Organisation, and on the transfer to the Meteorological Office of the Air Ministry in 1919 he became the first superintendent-in-charge, and was thus able to make the transition from private to official management easy for the five thousand voluntary observers.

Mr. Salter's health was always precarious, but he was nevertheless an indefatigable worker, and to the fact that no Medical Board would pass him for any form of military service is probably due the survival of the long-established system of rainfall investigation throughout the years of the War.

Mr. Salter served on the council of the Royal Meteorological Society and as a vice-president for many years; and he was an active member of the Institution of Water Engineers. He contributed numerous papers to these societies and to the *Meteorological Magazine*, of which he was joint-editor since 1913. He took a considerable part in the compilation of annual rainfall maps of the British Isles and of large-scale rainfall maps of many counties and other areas in co-operation with me, and after my retirement he carried the rainfall mapping of the country far towards completion. His little book "The Rainfall of the British Isles," published in 1921, gives an excellent account of the existing state of knowledge on the subject. In a paper on the fluctuations of annual rainfall considered cartographically, in collaboration with Mr. J. Glasspoole, read to the Royal Meteorological Society during his last illness, Mr. Salter gave an important discussion of the regional relations of rainfall and atmospheric pressure full of promise for future development.

For twenty-three years I found Mr. Salter a loyal fellow-worker and faithful friend, keenly intelligent, absolutely trustworthy, full of sympathy and consideration. I have pictured him writing my obituary notice; I never thought the natural order would be reversed. HUGH ROBERT MILL.

PROF. E. HAGEN.

THE issue of the *Physikalische Zeitschrift* for April 1 contains the account of the life and work of the late Prof. E. Hagen given by Prof. E. Gümlich at the meeting of the German Physical Society on March 9. Prof. Hagen was born at Königsberg on January 31, 1851, and losing his mother, who was the youngest daughter of Bessel the astronomer, in 1856, was brought up by a stepmother for whom he had a lifelong affection. On the removal of his father to Berlin he became a pupil at the local Gymnasium and in 1871 entered the University. After two years there he went to Heidelberg, where he graduated in 1875, having in the meantime acted as assistant to Bunsen. The next two years he spent at Dresden as assistant to Toepler and a further six as assistant to Helmholtz at Berlin.

In 1883 Hagen became a lecturer in the University of Berlin, and next year extra professor of applied physics at the Dresden Polytechnic. In 1887 he became physicist to the Navy and, removing to Kiel, acted also as extra professor at the University. In 1893 he became director of the technical section of the Reichsanstalt at Charlottenburg. He married in 1896 the daughter of Von Bezold the meteorologist, and in 1904 joined the staff of the German Museum at Munich. He died of inflammation of the knee on January 15. He was best known in this country for his work in conjunction with Rubens on the connexion between the electrical conductivity and the radiating and reflecting powers of metals.

IT is with much regret that we record the death of Dr. Elizabeth Acton, on Sunday, May 13, after a prolonged illness. Dr. Acton was a distinguished student of the late Prof. G. S. West in the botanical department of the University of Birmingham. In 1908 she took her Bachelor of Science degree with honours, and in the following year received the M.Sc. for research work in botany. After that time she was almost continuously engaged in botanical research, and in 1916 was awarded the degree of D.Sc. (Birmingham). Her contributions to the study of fresh-water algæ are of outstanding value, and her work throughout was marked by great thoroughness and painstaking accuracy. Her early death has removed a devoted worker from the sphere of botanical research. Dr. Acton's activities outside her scientific work were necessarily limited, owing partly to her continuous ill-health and partly to her retiring disposition. She was a loyal friend, and her uncompromising honesty was one of her chief characteristics. J. S. B. E.
E. M. P.

WE regret to announce the following deaths:

Prof. J. Chiene, emeritus professor of surgery in the University of Edinburgh and a friend and disciple of Lord Lister, on May 29, aged eighty.

Canon W. W. Fowler, president in 1901–2 of the Entomological Society, and author of "The Coleoptera of the British Islands," on June 3, aged seventy-four.

Prof. Franz Neger, professor of botany in the Dresden Technical College and director of the Botanical Gardens there, who worked with Baeyer for several years and published a thesis on dehydracetic acid, aged fifty-four.

Current Topics and Events.

THE immense progress which has been made in the elucidation of crystal structure by means of X-rays, since the first discovery of von Laue at Munich in 1912, and especially the quantitative development which has afforded the absolute distances separating the atoms, their actual sizes, and the dimensions of the space-lattice cells, is largely due to the invention of the ionising X-ray spectrometer by Sir William Bragg. The brilliant use made of that instrument at University College, London, and latterly also by an increasing number of other workers in various parts of the world, has been the means of accumulating a surprising amount of knowledge of the structure and structural dimensions of a large number of substances, many of the more recently studied of which are no longer of the simplicity of those first submitted to investigation. It must prove of interest, therefore, to our readers that we are able to present, as a supplement to the present issue, a revised form of an admirable lecture which was recently delivered by Sir William Bragg to the Royal Society of Arts. The most noteworthy fact which emerges from the accumulated results, including those derived from the photographic method of Laue and the powder methods of Debye, Scherrer, and Hull, is that the conclusions of crystallographers, based on the most accurate crystal measurement and on the perfected geometrical theory of crystal structure, are proved to be correct, both as regards the nature of that structure, and its relative unit-cell dimensions in those few cases in which it had been possible to determine them. These relative dimensions are now converted into absolute values by the X-ray spectrometric measurements. The recent venture into the more difficult field of organic substances is adding a further chapter of exceptional interest, and is of immense importance both to chemistry and to optics. The results have already had the happy effect of restoring the molecule to its proper place in the solid state, from which only a misreading of the first few results with the simplest inorganic compounds had temporarily displaced it. Moreover, they have rendered it clear that the number, nature, and arrangement of the external electrons of the atom itself are involved in cementing together the parts of the crystal structure, so that further work is bound to throw light on atomic structure, and possibly to decide between, or combine the correct portions of, the rival theories concerning it.

CIRCULAR No. 137, issued by the Bureau of Standards, U.S.A., is the fourth of a series of circulars describing very simple radio receiving sets which were originally prepared for use by the Boys' and

Girls' Radio Clubs of the States Relations Service, Department of Agriculture. In Circular No. 120 it was shown how a single circuit and in Circular No. 121 how a double circuit crystal-detector set could be made out of ordinary domestic materials. It is now shown how the operation of either set can be improved by the use of a very simple and cheap condenser connected across the telephone receivers and a similar one connected in series with the antenna. Clear instructions are also given for constructing a simple loading coil so that longer waves can be received. The condenser in series with the antenna makes it easy to tune to wave lengths of less than 300 metres, whilst the condenser across the telephone receivers increases the intensity of the signals. The loading coil enables time signals, etc., to be received from high power stations. The parts for the auxiliary condensers cost about 80 cents, and the parts for the loading coli about 3 dollars.

MESSRS. W. HEFFER AND SONS, Ltd., Cambridge, have just circulated a very full and useful catalogue (No. 224) of scientific books and serials numbering upwards of 2000 titles and classified under the headings of agriculture, husbandry, and farriery; anthropology and ethnology; botany; chemistry, chemical technology, and metallurgy; geology, mineralogy, and palæontology; zoology and biology; physiology, anatomy, and medicine; psychology and psycho-analysis; portraits of men of science; and mathematics, physics, and engineering. The list is especially interesting from the fact that many of the works are from the library of the late Sir William Ramsay. We note that Messrs. Heffer are offering for sale in one lot a large collection of books, pamphlets, and serials dealing with aeronautics.

THE cinematographic film, entitled "The Wonderland of Big Game," which Major A. R. Dugmore is showing at the Polytechnic Hall, Regent Street, London, is certainly one of the finest of its kind and deserves the attention of all interested in natural history. It is the result of a special expedition to East Africa made by Major Dugmore in 1922, and it is shown in connexion with a most charming and lucid explanatory lecture delivered by Major Dugmore himself. The outstanding merit of this film is its entire truthfulness and freedom from fake. It shows about thirty species, not only in their natural surroundings, but also under perfectly natural conditions, unharried by the big game hunter and usually unconscious of the presence of the harmless photographer. Save for occasional shots at lions, only one shot was fired at an animal during the expedition, and that was one intended merely to turn a rhinoceros from a headlong charge upon the camera. The animals are shown grazing at their ease upon the veldt, moving through the forest glades, or coming down to the water-holes to drink. The pictures of the common and Grevy's zebras, rhinoceros, elephant, buffalo, oryx and other antelopes, and, above all, of the reticulated giraffe are of very great interest; no one, with an experience wholly derived from Regent's Park, can imagine the grace of giraffes in free motion. The flashlight portraits of a lion and his mate also deserve special notice. Though perhaps less thrilling than some of the photographs of lions exhibited at other places recently, they are true to life, showing the animals as they normally behave, and not as they are when, infuriated by pain, they are held in a powerful trap, concealed by some convenient bush from the lens of the camera. Portions of the film will appeal also to those who are interested in anthropology, physical geography, and geology. Major Dugmore deserves success; and we hope that his lecture will draw large audiences for a long time to come.

THE work that has been carried on by the British Science Guild since 1905, with the object of bringing about a better public appreciation of the value of science, is in many respects unique. There is no body that has done more to bridge the gap between the public and the man of science. Among various matters of general interest that are now engaging the attention of its various committees may be mentioned the adequate representation of science at the British Empire Exhibition and the question of a British Empire patent. The Catalogue of British Scientific and Technical Books has proved a valuable piece of work, and it is satisfactory to note that sales and contributions have brought in a sum which almost equals the cost of production. The publication of a new edition is now being taken in hand. An interesting step has been the issue of publicity leaflets summarising recent scientific developments in popular form. The first of the series, by Prof. J. C. McLennan, deals with "Helium and its Uses." The production in mass of this non-inflammable gas for use in airships is a fascinating story, and there is no more striking example of scientific achievement during the War. The second leaflet, by Prof. J. A. Fleming, on "The Thermionic Valve" is now in preparation. There is no doubt that this new departure will be of service in promoting the objects of the Guild. Naturally, however, such propaganda work cannot be conducted without the "sinews of war." At the special meeting at the Mansion House on February 27, and again at the annual dinner on May 30, reference was made to the appeal now being issued by the Guild for contributions to form a fund of 50,000*l.* to enable its programme to be energetically developed. It is to be hoped that this appeal, which has received most influential support, will meet with a generous response.

THE second, or ladies', conversazione of the Royal Society this year will be held at Burlington House on Wednesday, June 20.

DR. A. BOWMAN, senior naturalist on the staff of the Fishery Board for Scotland, has been appointed superintendent of scientific investigations under the Board.

PROF. C. MOUREU, president of the Société Chimique de France, will deliver a lecture on "Les gaz rares des sources thermales, des grisous et autres gaz naturels" at the rooms of the Chemical Society, Burlington House, on Thursday, June 14, at 8.30 P.M.

H.R.H. THE PRINCE OF WALES has graciously accepted enrolment as an honorary member of the Institution of Mining Engineers and of the Institution of Mining and Metallurgy.

THE Board of Managers of the Royal Institution has elected Sir William Bragg to be Fullerian professor of chemistry, and director of the Laboratory and of the Davy Faraday Research Laboratory, in succession to Sir James Dewar.

THE list of honours conferred upon the occasion of the King's birthday includes the following names of men distinguished in scientific fields :—*Knights :* Mr. G. H. Knibbs, director of the Bureau of Science and Industry, Commonwealth of Australia ; Prof. W. J. R. Simpson, professor of hygiene, King's College, London ; and Dr. H. W. G. Mackenzie, senior censor, Royal College of Physicians. *Knight Companion of the Order of the Indian Empire* (*C.I.E.*), Mr. J. Evershed, director of the Kodaikanal and Madras Observatories. *Member of the Order of the British Empire* (*M.B.E.*), Mr. R. Ward, superintendent of the Botanic Gardens, British Guiana.

A limited number of fellowships for post-graduates in chemistry who are desirous of adopting an industrial career are being offered by the Salters' Institute of Industrial Chemistry to become operative in October next. The fellowships are of the annual value of from 250*l.* to 300*l.* each. Applications, with full particulars of training and experience, must reach the clerk of the Salters' Company, Salters' Hall, St. Swithin's Lane, E.C.4, before July 1.

UNDER the auspices of the Pontificia Accademia Romana dei Nuovi Lincei, a number of public lectures on subjects of scientific importance has been given recently in Rome. On April 26 and 27 Prof. C. J. de la Vallée Poussin, of the University of Louvain, lectured on functions of a real variable ; on April 28, Prof. G. Gianfranceschi, of Rome, dealt with the structure of the atom ; and on April 30, Prof. G. Boccardi, of the University of Turin, discussed the position of research on the variation of latitude. A lecture in commemoration of Louis Pasteur was delivered on May 2 by Prof. A. Anile, of the University of Naples, who dealt with the life and work of Pasteur. The addresses are to be printed and published by the Academy in due course.

THE Société Française de Physique, the headquarters of which are at 44 Rue de Rennes, Paris, was founded in 1873. There are now more than 1100 members, including 250 foreign members. Meetings are held twice monthly, and the transactions are published in a Bulletin. In addition to the Bulletin, members receive every month the *Journal de Physique et le Radium*, which publishes original communications, particularly on subjects dealt with at the meetings of the Society, and includes a review of a large number of French and foreign periodicals. Persons desirous of becoming members should send to the president a written application, supported by the recommendation of two members. The yearly subscription for foreign members is 65 francs, with an entrance fee of 10 francs.

IN connexion with the visit of H.R.H. the Prince of Wales to the East Hecla Works of Messrs. Hadfields, Ltd., to which reference was made last week, p. 759, we have received a description of the equipment of the works, including the research laboratories, which are provided with a very extensive range of instruments for the study and investigation of steels. In addition to the mechanical laboratories, in which alternating and impact tests are conducted as well as the older tests, there is a thorough equipment for the standardisation of pyrometers, whether thermo-electric, resistance, optical, or radiation. The apparatus in this section includes a Harker furnace for very high temperatures. Electrical and magnetic testing instruments are also included, in addition to the usual micrographic equipment. A feature of the department is the collection of specimens illustrating the researches which led to the discovery by Sir Robert Hadfield of manganese steel and of low hysteresis steel. Collections illustrating the early history of metallurgy were also exhibited on this occasion.

THE Board of Managers of the Washington Academy of Sciences has elected the following honorary foreign members in recognition of their prominence in their respective fields and their intimate connexion with scientific work in Washington : Prof. L. Manouvrier, Paris, for his work in anthropology ; Dr. C. F. A. Christensen, director of Universitetets Botaniske Museum, Copenhagen, for his services to systematic botany, particularly his monographic studies of tropical American ferns of the tribe Dryopterideae ; Dr. Paul Marchal, French Ministry of Agriculture, for his investigations in biological problems and their relation to agriculture, and especially for his research work in polyembryony ; Mr. E. C. Andrews, Government geologist of New South Wales, for his work in geology, particularly in the fields of origin of coral reefs, physiography, origin of the Australian flora, mountain formation, and origin of metalliferous deposits ; Sir Ernest Rutherford, for his distinguished work in chemistry ; Prof. F. Omori, professor of seismology, Imperial University, Tokyo, for his outstanding work in seismology ; Prof. G. Stefanini, Florence, for his investigations in palæontology and stratigraphy, especially the tertiary formations of Italy and echinoids in general ; and Prof. Max Weber, University of Amsterdam, for his work in zoology.

IN the Journal of the Franklin Institute for May, General Squier describes a method of transmitting the telegraph alphabet which can be applied to radio communication, telegraph lines, and submarine cables. Owing to the rapid expansion of radio telephony and telegraphy the problem of interference, both natural and artificial, has become one the solution of which must shortly become imperative. As there are only a limited number of lanes through the ether their conservation is of international importance. Radio waves are used very widely in navigation and for radio beacons. In addition, we seem to be on the threshold of another great development—"photobroadcasting," which will require and demand still more ether channels to serve the public of the near future. Radio telegraphy as conducted at present causes great disturbance. The power stations produce great explosions in the ether, the waves sent out having a wide range of frequencies which interfere with all forms of radio receiver. At present the radio engineer has utilised all the audio range of frequencies and several octaves of the radio frequency range. General Squier's plan is to utilise the infra audio range of frequencies, which are not used at present. An advantage of his system is that it cannot interfere with radio receiving. When applied to submarine telegraphy a modulating frequency of 10 per second corresponds to 75 words per minute, which is far higher than any form of sound reception.

AT a meeting of the Optical Society held on Thursday, May 24, Mr. R. S. Whipple, vice-president, in the chair, the sixth of the series of lectures on the evolution and development of optical instruments was delivered by Mr. David Baxandall, the subject being "Telescopes before the early part of the 19th century." The period from the time of Roger Bacon (d. 1292) to the beginning of the 17th century was dealt with at some length, particular attention being directed to William Bourne's description (1585) of a 12-inch perspective glass of about 15 feet focal length, which gave telescopic vision and magnified distant objects about twenty times. The invention of the telescope with concave eyelens by Hans Lippershey in 1608 was then dealt with and William Gascoigne's description of the way he arrived at the invention of telescopic sights quoted. The invention of the Gregorian and Newtonian reflecting telescopes was next referred to, and followed by a description of Hadley's reflector. The work of Chester Moor Hall, and the researches and work of John Dollond and Peter Dollond on the development of the achromatic lens, were also discussed. The lecture was illustrated by a number of pictures of old telescopes and by exhibits from the Science Museum, which included an early Italian telescope, and object-glasses or telescopes by various telescope-makers from the latter part of the 17th until the early part of the 19th century; the original glass negative made by Sir John Herschel in 1839; William Herschel's polishing machine, and the 7-foot reflector with which he discovered the planet Uranus. A number of these examples are from Mr. Thomas H. Court's collection in the Science Museum.

CAPT. R. AMUNDSEN hopes to undertake his projected flight across the North Pole about the end of June. After a visit to Nome, Capt. Amundsen returned to Wainwright, his winter quarters near Cape Barrow, the most northerly point of Alaska, in April last. The Norwegian Storthing has voted 60,000 kroner for an expedition to go to his support on the European side of the polar basin. In an article in the *Times* Mr. H. W. Sverdrup, second in command of the *Maud*, discusses the prospects of a successful flight to Spitsbergen or Cape Columbia in Grant Land. Capt. Amundsen has been provided by the United States Coast and Geodetic Survey with a Fischer sextant with an artificial horizon. This should allow him to measure the altitude of the sun with an exactness of 10′ to 20′ and possibly 1′ to 2′. If, however, the sun is obscured, Capt. Amundsen will require to fly by compass only. In this case he will have to change his course every now and then in order to follow a meridian from Point Barrow to the Pole, whereas from the Pole a constant course can be kept. If solar observations are impossible, there is only the actual flying time on which to calculate the position. Sixteen hours from Point Barrow should take the airman to the Pole, from which a compass course of N. 171° W. should land him on Spitsbergen. The difficulty will be to estimate leeway, etc. A contrary wind of about 10 metres a second would allow the aeroplane to reach only lat. 85° N. after sixteen hours' flight, and a course of N. 171° W. from there would take it to the New Siberia Islands. Mr. Sverdrup agrees that the prospects for a successful flight to Cape Columbia must be considered more favourable.

AT the annual meeting of the Illuminating Engineering Society on May 24, the report of the Council contained a summary of much varied and useful work. A joint committee, on which the Society and educational bodies will be represented, is to be appointed to consider courses of instruction in illuminating engineering, and the preparation of a suitable textbook for the use of students. Dr. J. F. Crowley presented a paper on "The Use of Synchronously Intermittent Light in Industry," which was illustrated by some striking experiments. The development of the neon lamp, which can be completely extinguished and lighted at a high frequency, has revolutionised methods and led to important industrial developments. By the aid of an oscilloscope utilising such lamps fed by an alternating current of regulated frequency, the motions of a high-speed machine can be apparently slowed down until they are almost stationary. Thus the movements of the mechanism of a sewing machine, illuminated by the intermittent light of a neon lamp, can be followed with perfect ease and any small irregularities observed at leisure. The method has been applied to many problems involved in textile machinery, where exact and regular speed-regulation is of great importance; and in other cases it is possible to detect and observe such phenomena as undue play at bearings, effects with whirling shafts, etc., which are quite unrecognisable by ordinary steady light. Mr. P. R. Ord also demonstrated the use of the Nutting-Hilger spectrophotometer for the comparison of natural and artificial daylight, an apparatus which affords valuable information on the colour-revealing qualities of such lighting units. A number of curves were shown to illustrate the departure from normal daylight and the extent of the variations in the spectrum of daylight at different times in the day.

MANY optical instruments, in the construction of which prisms form an essential part, are grouped together in a new catalogue which has just been issued by Mr. John Browning, of 37 Southampton

Street, Strand, London, W.C.2. A wide range of direct-vision pocket spectroscopes, some with and some without comparison prisms and micrometer scales, is included, together with larger portable sizes fitted with collimators. Among the table spectrometers manufactured by the firm is one of an auto-collimating type in which the telescope has an object-glass of 1 in. diameter and 9 in. focal length. The circle is 5 in. in diameter with two verniers reading to 1′. Other instruments described are stereoscopes, prismatic compasses, prismatic field and opera glasses, and there is also included a short, light-weight telescope having a Porro prism erecting system and fitted with a revolving adapter carrying two eyepieces giving magnifications of 10 and 15 respectively; this should prove useful to the tourist or naturalist. Simple explanatory notes describing the construction, use, and adjustment of the various instruments increase the usefulness of the catalogue.

THE latest catalogue (No. 444) of Mr. F. Edwards, 83 High Street, Marylebone, W.1, is devoted to biography and history. It contains a short list of lives of men of science, reasonably priced.

A TRANSLATION, by Jessie Elliot Ritchie and Dr. J. Ritchie, of Prof. H. Boule's "Les Hommes Fossiles" is to be published shortly by Messrs. Oliver and Boyd, Edinburgh, under the title of "Fossil Men: Elements of Human Palæontology." The work has been brought up-to-date by the addition of notes by the author.

As many of the works on natural history published by the Trustees of the British Museum (Natural History) are out-of-print and difficult to obtain, a list of the volumes on sale by Messrs. Wheldon and Wesley, Ltd., 2 Arthur Street, W.C.2, should be of interest to many readers of NATURE. The catalogue, classified according to subjects, is New Series, No. 7. It can be had upon application to the publishers.

THE Cambridge University Press is to publish this summer, under the title of "The Domain of Natural Science," the Gifford Lectures delivered by Prof. E. W. Hobson in the University of Aberdeen in 1921 and 1922. The work is an attempt to settle the relation of "that complex of knowledge and ideas which is denoted by the term natural science" to religion and philosophy at the present day. To attain this object the author has examined the historical development, aims, and true characteristics of the various departments of natural science. Vol. xviii., Q–S, of the Royal Society of London Catalogue of Scientific Papers, Fourth Series, will be issued by the same house immediately.

Our Astronomical Column.

JUNE METEORIC DISPLAYS.—Mr. W. F. Denning writes: "Sometimes a fair number of meteors are to be seen during the short nights of June, and there are many radiants visible, but they are so feeble that unless the observer maintains long vigils he will not gather sufficient paths to indicate the places of radiation accurately.

"Some of the chief radiants at midsummer are:

213° + 53°	245° + 64°	252° − 13°	252° − 23°
260° − 12°	260° − 22°	261° + 5°	280° − 13°
272° + 68°	282° − 24°	354° + 40°	355° + 77°

Considering that the twilight is strong and persistent during the whole of the night and that therefore the conditions are not favourable, the meteors are often more in evidence than would have been expected. The nights of June are also so agreeable for outdoor work that this particular time of the year is an attractive one to the student of meteors. It is true that what may be termed the real opening of the meteoric season occurs at the middle of July, but June anticipates a few of the advantages of the former month in a minor degree.

"The Perseids possibly commence to display the vanguard of their coming host at the end of June, and this question needs further attention. A few meteors exhibiting all the characteristics of the Perseids have been recorded so early as June 25-26 and with conformable directions, but it is just possible that other showers may have been responsible. To ascertain the truth two observations at distant stations are required, and observers should make special efforts to obtain them during the last week in June and first week in July. If this endeavour were thoroughly carried out we should soon acquire the necessary evidence and discover the opening date of the great Perseid shower. It is by far the finest annual display exhibited in the heavens and lasts for a longer period than any other stream, for late Perseids are seen until about September 5 and 6, when the radiant is at 90° + 57° on the N.E. boundaries of Auriga."

THE CORONA OF 1908 AND SOLAR PROMINENCES.—In the Memoirs of the Kodaikánal Observatory (vol. 1, Pt. ii. p. 67) Mr. Evershed referred to the corona of 1908 as affording a test of the relationship of prominences to coronal streamers, because the Kodaikánal photographs of prominences showed considerable activity over the sun's south polar region and an almost complete absence over the north pole. In Mon. Not. R.A.S. vol. 83, p. 153, he returns to this subject because, as he says, "the corona, as drawn by the late Mr. Wesley from photographs obtained at Flint Island by Mr. McClean, shows the opposite distribution as regards the coronal streamers, which are more conspicuous over the north polar region than over the south, and thus the test in this instance appears to fail, although from previous eclipses there seemed to be a close correspondence between the coronal streamers and the principal zones of prominence activity." Mr. Evershed was therefore led to re-examine the orientation of the Flint Island photographs in relation to his own prominence photographs and Dr. Campbell's published photographs of the corona. He has now come to the conclusion that the north and south points on Mr. Wesley's drawings should be interchanged.

Mr. Evershed concludes that "Dr. Campbell's orientation is correct and that the corona of 1908 is not an exceptional case, but, on the contrary, adds weight to the evidence previously found for a close relationship between prominences and coronal streamers as advocated by Major Lockyer in his recent and also his earlier paper."

Research Items.

STEATOPYGOUS FIGURES FOUND IN FRANCE.—Female figures with that remarkable conformation known as steatopygous have been found in southern Europe from time to time, and have been connected with the peculiar build of Bushmen-Hottentot women. A figure of this kind discovered at Lespugue, Haute-Garonne, is described by Dr. René de Saint-Périer in *L'Anthropologie*, vol. xxxii. No. 5-6, with a useful list of references to other figures of the same kind.

BALKAN EMBROIDERY PATTERNS.—In the May issue of *Man* Miss Edith Durham publishes a series of interesting embroidery patterns from the Balkan Peninsula. Those worked in cross-stitch are generally used by the Slav-speaking peoples, those in chain-stitch by the Albanians. Up till very recent days embroidery was used lavishly on the garments of both men and women. The superiority of the Albanian as a designer is marked in this series. He is the artist of the Balkans, and the curvilinear patterns run through the inlaid metal work and carving, which is now fast dying out. He is usually his own silversmith, and the rough ornaments which he makes are extraordinarily like those found at Glasinatz, which include little doves pierced to wear as amulets.

"SHEEP-TRACKS" ON GRASSY SLOPES.—Close-set grassy ridges running parallel along the surface of a bank are familiar in many countries, and almost everywhere the popular explanation of their presence is that they are due to the traffic of sheep. Hilmar Ødum, of the Danish Geological Survey, has recently made a study of their appearance and development in the Færöe Isles and in Denmark, and finally disposes of the myth of their zoological origin (*Danmarks geolog. Undersøg.*, Ræk. iv. Bd. 1). He finds that the formation of the ridges, which he names "terracettes," originates in a settling of the loose earth on an unstable slope into a position of greater stability. At first a series of horizontal cracks appears in the turf covering a steep slope, then the narrow turf section between two cracks sinks slightly, turning at the same time about a horizontal axis, so that its surface comes to rest at an inclination rather less steep than that of the slope as a whole. The ridges, once begun, increase in definiteness, owing to the filtering out by the grassy coating and final settling of soil particles washed down by rain. The whole process is of a superficial character and is entirely a geological phenomenon.

THE POPULATION OF INDIA.—In anticipation of the report on the Indian Census of 1921, Mr. J. T. Marten, Census Commissioner, gave an interesting review of the results in a lecture delivered before the Royal Society of Arts and published in the Society's Journal of April 6. The economical conditions of the country suffered naturally from the effects of the War, and the difficulties attending the enumeration were increased by the failure of discipline among the people resulting from political unrest. The most interesting departure on this occasion was the attempt to extend the census of industries, but the weakness of the Industrial Department has made the result somewhat disappointing. Mr. Marten remarks: "We have a population with very considerable natural capabilities of increase. That increase is checked by ignorance of and indifference to maternal and infant welfare, by occasional famines and by epidemics, such as malaria, plague, and influenza. We endeavour year by year to minimise the effect of these checks. What if our endeavour should be successful? Can India support a considerable increase of population in the future under any conditions that seem likely to arise? If not, which is to lead the way to economy, the birth-rate or the death-rate, and will the other follow? In this connexion we have made some tentative efforts to collect in some provinces, where circumstances seemed most suitable, on special schedules, some statistics of the size and sex constitution of families in different social strata, with a view to obtaining information as to the normal fertility of married couples. The attempt is beset with difficulties."

CHROMOSOMES IN MAN.—The number of chromosomes in man has long been uncertain. In 1914 von Winiwarter published the most trustworthy account, finding 47 chromosomes in male germ cells and inferring 48 in the female. Other investigators found 24, and at one time it appeared that this half number was characteristic of the negro. Dr. T. S. Painter (*Journ. Exptl. Zool.* vol. 37, p. 29) has recently published a paper which probably settles the matter. He finds 48 chromosomes in both the white man and the negro. The reports of 24 were probably due to clumping of the chromosome pairs before fixation. Dr. Painter finds that the 48 chromosomes include an X-Y pair of sex-chromosomes. The Y-chromosome is very small and was probably overlooked by von Winiwarter. Painter also finds giant spermatogonial cells with larger nuclei and twice as many chromosomes (approximately 96). The occurrence of giant spermatozoa has long been known. If they are functional then triploid individuals might arise, and it is pointed out that some of these with new combinations of sex-chromosomes might be intersexes or hermaphrodites, such as have been shown to occur in a similar way in Drosophila.

MINERAL CONSTITUTION OF SOIL-TYPES.—James Hendrick and George Newlands (*Journ. Agric. Science*, 1923, p. 1) have examined the mineral particles constituting the more sandy grades separated from the "fine earth" of a number of British soils, dealing with the material finer than 3 mm. in diameter. They find that the separation of different minerals is practically impossible for grades below the "fine sand" of English workers—that is, finer than 0·04 mm., a figure that should have been stated. The coarser grades, however, can be divided mechanically, magnetically, and microscopically, into an "orthoclase group," including all the felspars, a "quartz group," and a "ferrosilicate group." A number of minerals, such as zircon, garnet, and tourmaline, that are "accessory" in the parent rocks appear in "surprising amount" in the soils, owing to their resistance to abrasion and decay. A greater surprise is the constant record of granular hæmatite, side by side with scaly yellow limonite. The authors hope that such investigations may be of service as showing the reserve of bases present in the silicate particles. The fresh state, however, of many of the felspars suggests that the agriculturist has little to gain from the coarser grades, apart from their influence on soil-texture, unless, as is quite possible, chemical exchanges take place on the surfaces of the grains. It is well, indeed, that the study of adsorptive reactions should not be entirely restricted to the colloidal field.

LAND MOLLUSCA OF THE SOUTH-WESTERN UNITED STATES.—In the year 1905 Dr. H. A. Pilsbry published the first of a series of memoirs on the "Mollusca of the South-western States." Later instalments were mostly written in collaboration with J. H. Ferris, and now the eleventh part by these two well-known American malacologists has just come to hand (Proc. Acad. Nat. Sci. Philad., vol. lxxv.). It is as admirable both in descriptions and figures as its predecessors, and deals principally with those members of the Helix family that inhabit the desert lands of Arizona. The genus Sonorella dwells in colonies in the interstices of the screes and tumbled talus of the volcanic rocks forming the hills of that arid and sparsely inhabited region, seldom coming to the surface save in very wet weather. Their collection is therefore an arduous matter only to be undertaken by a properly equipped expedition. The prospective interest lies in the fact that each group of hills seems to have largely its own species, or variety of snail, and that when the whole area has been surveyed important deductions as to the physical geography of the past may be built up on the evidence of the distribution, past and present, of these molluscan forms.

DORSAL EYES OF THE SEA SLUG.—K. Hirasaka (*Annot. Zool. Japon.* x., Art. 17, Dec. 1922) gives an account of the dorsal eyes of the amphibious sea-slug *Onchidium verruculatum*, which occurs abundantly near the Marine Biological Station at Misaki. The dorsal surface of the slug bears numerous papillæ of varying size, some of which are provided with eyes, one to seven in number. In the posterior third of the body some of the papillæ are of large size and branched, forming the respiratory "gill-trees." Semper stated that the eyes decrease in number as the slug grows, and he put forward the view that the eyes were in course of degeneration; but the present author shows that Semper was mistaken in his belief that the eyes disappear as growth proceeds. The cornea of each eye consists of modified epidermal cells, below which is a fibrillar connective tissue forming a circular sheet containing in its peripheral parts circular and radial muscle fibres. The lens is composed of a large distal cell and a small proximal group of cells, the former differentiated into a distal, spherical, more or less homogeneous body, and a basal cup-shaped part containing the nucleus. Early in development this cell exhibits a nerve issuing from its base, but the nerve becomes atrophied in the fully developed eye. The proximal lens cells form a group of usually three or four nucleated cells. Lining the proximal two-thirds of the pigmented cup which envelops the eye is the retina—a single layer of cells loosely packed together, and imbedded in connective tissue. In the basal part of each cell is a large lumen filled with a coagulable substance, and proximally the cell tapers into a nerve fibre which enters one of the nerves passing to the pleural ganglia.

MINERAL FERTILISERS.—As a result of three years' residence on the island, Launcelot Owen (Quart. Journ. Geol. Soc., vol. lxxix. p. 1, 1923) describes the deposits of tricalcium phosphate that are exploited in Ocean Isl., a member of the Gilbert group. These have originated in guano, which gathered in the hollows of a "karrenfeld," worn out of upraised coral-limestone. The fantastic features of this old surface of erosion have been well illustrated by G. S. Robertson in his work on "Basic Slags and Rock Phosphates" (1922), where views of the similar surface of Nauru Isl. are also given. L. Owen states that the loose friable phosphate is in no sense alluvial, but results from the aggregation of concretions. The coral-rock, including the pinnacles, became dolomitised, and was then permeated by the phosphate down to a depth of fully fifty feet. A level exists where the percentage of tricalcium phosphate sinks from its normal 88 to 79 per cent., and below this no phosphate deposits of any extent are found. The author (p. 13) rejects the idea of the occurrence of compounds such as dahllite and apatite, and is apparently unaware that the rock of Sombrero, once regarded as pure tricalcium phosphate, is now proved to consist of dahllite. He notes (p. 6) the occurrence of a translucent isotropic and amorphous phosphate, which he regards as colloidal. This is possibly the substance for which A. F. Rogers revived the name collophane in 1922. As a contribution to our knowledge of potassic fertilisers, the U.S. Geological Survey (Bull. 727, 1922) has published G. R. Mansfield's investigation of "Potash in the Greensands of New Jersey," with maps showing the distribution of the sands and marls. The general characters of glauconite as a fertiliser are now well known; its application to the land is beneficial, though it may not equal in effect the recently described "potash shales" of Illinois (Illinois Univ. Agric. Station, Bull. 232, 1921.)

SYNTHETIC MARBLE.—The generally accepted theory of the igneous formation of marble rests on crude experiments made by Hall (1801–3), in which chalk was heated in a closed gun-barrel. In the April number of the Journal of the Chemical Society Dr. M. Copisarow describes some interesting experiments, which tend to support an aqueous origin of marble. When solid calcium chloride and hydrated sodium carbonate, or a paste of precipitated chalk and sodium chloride solution were heated in an autoclave at 300° at a pressure of 24 atmospheres for 8 hours, a compact mass of marble, capable of taking a high polish, was formed. The salts present facilitated the solution of the chalk or other form of calcium carbonate and the high pressure conditioned crystallisation. When sodium sulphate was used with calcium chloride a compact mass of alabaster was formed.

SEA-LEVEL CHANGES IN DENMARK.—An investigation of a submerged peat-bog in the harbour of Rungsted, Denmark, by Dr. Knud Jessen, of the Danish Geological Survey, has revealed considerable changes in relative levels of sea and land in the neighbourhood of Copenhagen during the late-glacial period (*Danmarks geolog. Undersøg.* Ræk. iv. Bd. 1). About 260 metres off the coast, and at a depth beneath the surface of the sea of some 20 metres, was found a fresh-water clay—"Dryas-clay"—containing land plants, and this was overlaid first by deposits containing, among other things, bones of a vole and of a wild pig; secondly, by peat containing oak, alder, hazel, etc.; and, finally, by sea-mud with cockle shells and recent sea-sand. The indications seem to be that, at the beginning of the late-glacial period, the sea was 18 metres higher at Copenhagen than now, and that elevation of the land took place later, so that at the end of the late-glacial period it stood at least 24 metres above its present level relative to the sea; this elevation persisted from the younger Dryas-period till the Littorina submergence, which finally broke the land-connexion between Seeland and Scania.

VERTICAL MOVEMENTS OF THE ATMOSPHERE.—Mr. I. I. Kassatkine, in his monograph of the above title which has been published in the Bulletin of the Imperial Society of Naturalists in Moscow, 1915, puts forward a theory of rain formation. According to this theory, upward currents of air, on reaching the cloud level, cause still further separation of moisture by raising the clouds. The drops thereupon coalesce to form larger ones, which will eventually attain a size such that they can fall against the direction of the upward current, instead of being carried up still higher. Whether these drops reach the earth's surface or not will depend on the nature of the layers of air through which they must pass. If the latter are dry, and the upward current strong, they will have evaporated away before reaching the earth. If the height of the clouds is h_s, and the height to which they are lifted is h_b, then, before any rain can reach the earth, the ratio h_s/h_b must attain a limiting value a, which for Moscow has a value which varies from 2·5 to 3·5; when its value falls below this, irrespective of the degree of cloudiness, no rain can fall. The anomalously low rainfall of Swakopmund is explained, on this basis, to be due to the presence of a pronounced inversion caused by the sea-breeze, below the average cloud level, which inhibits the development of upward currents. Farther inland, where this factor does not exist, the rainfall is much greater.

PROJECTION FOR AERONAUTICAL MAPS.—In 1919 the International Aeronautical Conference decided to adopt the Mercator projection for the general small-scale air map. In the Geophysical Supplement (vol. i. No. 3) of the Monthly Notices of the Royal Astronomical Society, Col. E. M. Jack and Capt. G. T. McCaw contribute a paper on the value of Mercator in this connexion, answering criticisms that have been made regarding its adoption. The substance of the paper was read to the British Association at Hull. The essential value of these small-scale maps is for aerial navigation; that is, for the direction of the course of the aeroplane from one point to another. In consequence it applies not to local large-scale maps but to maps on a scale of 1 : 2,000,000 or 1 : 3,000,000. In most criticisms of Mercator, the use of the polyconic has been advocated. The authors reply to these arguments by pointing out that the disadvantages of the polyconic are threefold—the sheets do not fit together, the measurement of bearings is less simple and direct than in Mercator, and, with a single exception, no straight line represents anything in Nature save as an approximation. On the other hand, a good case is made for the use of Mercator, even if that projection, in common with all others, has some obvious defects. The authors answer the criticisms at length, but point to the essential quality that Mercator possesses, of representing a line of constant bearing as a straight line, as being of prime importance to the navigator. The varying scale does not trouble the aviator, but the bearing line enters into almost every problem with which he has to deal. Mercator enables him to solve these problems by simple graphic means, and, as a result, he prefers it to any other projection. At the same time the authors admit that, if flying beyond lat. 70° becomes common, some other projection will need to be used for polar regions, but this does not affect the problem at present.

FREE-AIR PRESSURE MAPS FOR THE UNITED STATES.—Supplement No. 21 to the U.S. *Monthly Weather Review* is a discussion on "the preparation and significance of free-air pressure maps for the central and eastern United States," by Mr. C. Le Roy Meisinger. The aim of the author is to develop barometric maps of free-air levels which shall have a direct and important bearing upon accurate forecasting for aviation. The discussion opens with "the history and problems of American barometry," and an explanation is given of the relations involved in the reduction of pressure from one level to another, temperature introducing a considerable difficulty. The author, referring to practical experience being required to demonstrate the value of free-air pressure maps, and stating that the United States does not possess this experience, mentions that in Japan daily maps of the 3-kilometre level have been drawn for several years and are of great service to Japanese forecasters. Details are given of Dr. R. Sekiguchi's experience in forecasting from these maps in Japan. Cyclonic centres in the Far East show better agreement with the trend of the isobars on the 3-kilometre maps than with that at sea-level. Various interesting examples are given, and probably valuable information may be gained from these for other parts of the globe. A large number of specimen maps are shown for sea level, 1-kilometre level, and 2-kilometre level, while details are given of each series. The work is of considerable importance to aviation, and the upper-air charts show what the winds are doing aloft when it is often impossible to gain the information from the sea-level charts. It is claimed that the discussion affords a glimpse of the physical processes at work, and may help to lift us from empiricism a little nearer to that ultimate goal toward which students of weather forecasting are striving.

ENDURANCE LIMIT OF STEELS.—Engineering Bulletin No. 136 of the University of Illinois contains an account of further experiments on the fatigue of metals, conducted by H. F. Moore and T. M. Jasper. The new results, which have been obtained by similar methods to those described in a former Bulletin, confirm the existence of a true endurance limit for steels of different compositions. For moderately hard steels, this limit may be found by rapid tests in which the rise of temperature is measured. Only a few preliminary tests have been made by Gough's method of determining the increase of deflexion as the range of stress is increased. A fairly close correlation is found to exist between the endurance limit and the ultimate tensile strength or the Brinell hardness, and a much less close connexion between the endurance limit and the yield point and limit of proportionality, there being no correlation with the impact or repeated impact values. It should be remarked, however, that the range of materials studied was not very wide, and the authors did not examine defective materials. A formula for the effects of cycles of stress not involving complete reversal is proposed, the results not being in agreement with Goodman's diagram.

A NEW FILAMENT ELECTROMETER.—In the issue of the *Physikalische Zeitschrift* for April 15, Dr. C. W. Lutz, of the Geophysics Observatory, Munich, describes an improved form of filament electrometer, which has been constructed by the firm of Edelmann, for use in the observatory. The filament is of platinum, and its lower part is attached to one end of a diameter of a circular loop of quartz fibre; the other end of the diameter of the loop being attached to the sliding frame by means of which the whole may be removed from the instrument for replacement of the filament. The deflectors between which the filament is placed are adjustable by means of screw heads outside the metal cover of the instrument. The filament is observed through a microscope magnifying 285 times, and, for distances of the deflectors from the filament exceeding 4 mm., the deflexions are proportional to the applied volts over the whole of the scale of the ocular of the microscope, which is graduated from a central zero to 50 on each side. The insulation throughout is amber. The sensitivity of the instrument may be varied by the usual methods from 0·001 to 2 volts per division of the scale.

The Royal Observatory, Greenwich.

ANNUAL VISITATION.

THE visitation of the Royal Observatory took place on Saturday afternoon, June 2. In addition to members of the Board of Visitors a large number of guests interested in astronomy were present, and took part in the inspection of the observatory and instruments.

The astrographic equatorial has been remounted on its return from Christmas Island, and the instruments left in Russia in 1914 have just arrived safely after an absence of nearly nine years. The Astronomer Royal in his report expresses his regret at the failure of the Christmas Island expedition; he notes, however, that the close verification of the Einstein shift by the Lick Observatory expedition renders it unnecessary to send an expedition from Greenwich to observe the Californian eclipse next September.

The exchange of wireless signals has reopened the question of the small differences of time-determinations at different observatories. Examination of the bearings of the transit circle showed that the western pivot was bearing only on its eastern edge; this was remedied by a slight lowering of the bearing. The test was made by placing some rouge on the bearings, then lowering and rotating the instrument; the presence or absence of rouge on the pivot showed where it was in contact with the bearing.

The results of the wireless time comparisons for the year are given; the annual means are Paris +0·10 sec.; Bordeaux +0·14 sec.; Nauen 0·00 sec.; Annapolis (August to December only) +0·03 sec. The plus sign means that the other station is late on Greenwich. In the case of Annapolis, the discordance is wholly explicable by the time of transmission; 0·06 sec. of the Paris and Bordeaux discordances is due to the fact that Leverrier's Tables of the Sun, used in France, differ by this amount from those of Newcomb. In the long run these differences will probably give excellent determinations of longitude.

Observations of the moon are dealt with in special detail in the present report, on account of the fact that Hansen's tables, used in the "Nautical Almanac" from 1862 to the end of 1922, have now been superseded by those of Brown. This was, therefore, selected as a suitable occasion for collecting all the Greenwich observations of the moon made since the time of Bradley, and reducing them to Brown's system (modified by using Fotheringham's secular acceleration, which is 4·79″ in excess of Brown's). It was then found that the residuals could be represented by two empirical terms, one with amplitude 3″ and period 70 years, the other with amplitude $1\frac{1}{2}''$ and period 59 years. The two terms are now in unison, producing a large oscillation, but in Bradley's time they tended to neutralise each other. A full comparison is given between Brown's Tables and observation for the first quarter of 1923; there is a nearly constant error in longitude of −7·8″, about half of which is due to Brown's use of too small an acceleration.

Observations with the Cookson floating telescope, lent by Cambridge Observatory, are being continued. Mr. Jones has revised his determinations of latitude variation with this instrument; and they are in satisfactory accord with those made elsewhere. One of the seven-year maxima of latitude variation is due about 1923. The 28-inch equatorial is being used for observation of close and difficult pairs; 66 pairs with separation less than 0·5″, and 105 between 0·5″ and 1·0″ have been observed during the year. Mr. Jackson is continuing to deduce hypothetical parallaxes for these and other stars.

The 26-inch refractor is being used for photographic determinations of stellar parallax; 49 parallaxes have been determined during the year, making a total of 195 with the instrument. The 30-inch reflector is being used for photography of stellar spectra with a combination of prism and grating. A principal spectrum is thus obtained, bordered by diffraction spectra of known relative intensities, thus determining the density gradient of the plate for all wave-lengths. With the astrographic equatorial some of the fields photographed about twenty years ago are being re-photographed through the glass, so that superposition on the earlier plates, film to film, enables proper motions to be deduced. The work has begun with zone 65° N. Declination, and will gradually approach the pole.

Sunspot activity continues to decline. There was, however, a considerable group of spots visible from December 22 until January 4 in latitude 6° N. A high-latitude spot in 41° S. was photographed on November 14 and 15.

The following are the provisional magnetic elements deduced for 1922:

Declination 13° 46·6′ W., Dip 66° 51·9′, Hor. Force 0·18449, Vert. Force 0·43181 (the last two being in C.G.S. units).

The weather report is for the twelve months ending April 30, 1923. The mean temperature was 49·8° F., being 0·2° above the average. On two days, both in May, the temperature reached 90° F. It fell to freezing-point on 21 days. There were 1404 hours of bright sunshine, 31·5 per cent. of the possible amount.

The Astronomer Royal naturally refers to the severe loss which the Observatory has sustained in the death of Mr. W. W. Bryant, noting his enthusiasm in former years as a meridian and double-star observer, and the zeal and energy with which he afterwards carried on the work of the Magnetic and Meteorological Department. Allusion is also made to the astronomers who have visited the observatory for special purposes during the year; they include Mr. Dodwell, director of Adelaide Observatory, Messrs. Comrie and Greaves from Cambridge, and Mr. S. Gaythorpe, who came to study the Horrocks MSS. in connexion with a biography of Horrocks which he is preparing.

A. C. D. C.

Royal Visit to University College and Hospital, London.

ON Thursday, May 31, the King, who was accompanied by the Queen, opened the new Institute of Anatomy at University College, London, and laid the foundation-stone of the new Obstetric Hospital. Her Majesty laid the foundation-stone of a Nurses' Home which is to be erected on an adjacent site in connexion with University College Hospital.

Before a gathering as brilliantly representative of the science and practice of medicine as of philanthropy and affairs, his Majesty said there could be but few instances on record in which any foundation had received 1,200,000*l.* from a single benefactor in a single gift. The magnificent generosity of the Rockefeller Trustees is the more impressive since it was bestowed by a citizen of the United States of America upon a college and hospital in London, and thus upon the people of Great Britain and the Empire. The declared purpose of the trustees is "to promote the well-being of mankind throughout the world." That they should have selected the University of

London to receive this princely endowment is not merely a high and well-deserved compliment and the creation of yet another tie of sympathy and friendship linking us to the United States; but it is also the evidence and declaration of their conviction that the progress of science and the welfare of mankind are not delimited by national or racial boundaries, and that work done in London for the relief of human suffering, the improvement of medical education and the advance of science, is a service to the whole world. The advance of knowledge and the ever-rising standard of medical education necessitate reorganisation which would give an impetus to the more effective training and equipment of the British practitioner. The underlying principle is as old as Ecclesiasticus: "The wisdom of a learned man cometh by opportunity of leisure, and he that hath little business shall become wise." Its specific application to medical teaching and research is new.

Continuing, the King referred to her Majesty's particular satisfaction on learning that the care of maternity and infant life, in which the Queen has always been actively interested, is part of the scheme, and that the claims of the nursing service have not been overlooked. The privilege of accepting the munificent gift of the Rockefeller Trustees imposes obligations upon the staff to fulfil the ideals which it represented, and upon the public to furnish necessary support. It is inconceivable that Englishmen should decline to welcome this generous challenge from our kinsmen across the Atlantic to a friendly rivalry in medical skill, devotion, and beneficence. His Majesty cordially wished Godspeed to this great enterprise.

The address was followed with responsive attention, and when the stones were laid their Majesties proceeded to the library of the Medical School and thence to the new building of the Institute of Anatomy. A tour of the building was made, their Majesties being particularly interested in the brilliantly-lighted dissecting-room and the equipment of the X-ray rooms, where the director of the Institute, Prof. G. Elliot Smith, demonstrated various radiographic and anatomical exhibits, among them plates taken twenty years ago of the mummy Thothmes IV., and whole specimens made transparent by the Spalteholz method to facilitate comparison with X-ray plates by students of anatomy. Both their Majesties were also keenly interested in radiographic plates and photographs shown by Mr. H. A. Harris revealing the effect of successive illnesses upon the growth of the long bones of a child.

The Mind of the Maori.

THE authorities of the Dominion Museum at Wellington, New Zealand, have published a series of monographs on the ancient institutions, mental and spiritual concepts, and ceremonies of the pre-European Maori, with an examination of the esoteric meaning underlying innumerable personifications and mytho-poetic allegories. They are written by Mr. Elsdon Best, who is regarded as the greatest living authority on Maori history and folklore.

In the first paper mentioned below,[1] stress is laid upon the two different phases of Maori religion. The ritual and teaching of the priests and men of superior rank were of a distinctly higher type than that of the common people. They formed the most intensely *tapu* portion of Maori esoteric lore and were so jealously guarded that for many years they were entirely unknown to Europeans.

Mr. Best's account of Maori myths is derived from the East Coast tribes. There is an elaborate cosmogony. Things celestial and terrestrial are spoken of as persons, and the processes of evolution are described in genealogical form. In the beginning was the vast unknown time of Po, before Rangi and Papa (sky and earth) appeared. From the union of these arose certain supernatural beings whose names are known throughout Polynesia—Tane, Tu, Rongo, Tangaroa, Tawhirimatea, and Whiro. These beings formed and arranged the present world. Mr. Best gives a highly poetical account of their varied exploits, and in some of the concepts finds a likeness to ancient beliefs in Chaldea, Egypt, India, China, and Japan. The cosmogonic genealogy of Rangi and Papa, which in one account consists of such names as Pu (root), More (extremity), Take (stump), Weu (fibre), is compared to the World-Tree of Scandinavian myth, and the three baskets of knowledge obtained from the heavens by Tane are likened to the three baskets or books of knowledge of the Indian Buddhists.

Mr. Best describes four classes of Maori gods. The first, alone, is Io, the supreme deity, then come the departmental and tribal gods, and lastly, the spirits of dead ancestors. The startling suggestion is made that the name Io may be a form of Jehovah. Several other gods are compared with those of Egypt and Assyria.

The Maori conception of the spiritual nature of man is concisely stated by Mr. Best in the following account from a native: "The conclusions he arrived at from what he considered clear evidence were—that man possesses a spiritual quality that leaves the body during dreams and quits it for ever at the death of the physical basis (this is the *wairua*); that death is marked by the passing, the extinction, of an invisible activity called the *manawa ora* (breath of life); that man also possesses a physical life-principle termed the *mauri*—one that cannot desert the living body but does so at death; that he possesses yet another life-principle called the *hau*, that can be affected by the arts of black magic; that man possesses several sources of mental and intellectual activity, and that the semblance of man, or of any entity, may be taken and employed as a medium in ceremonies believed to affect the originals."

The papers on astronomical knowledge and the division of time are remarkable examples of Mr. Best's intimate acquaintance with the lore of the Maori people. The Maori named the heavenly bodies and accounted for them in myths; they used them as time measurers and guides in navigation; and they personified them and worshipped them as benefactors and deities.

In these papers Mr. Best has given us a highly interesting and in many places an intensely poetical account of the speculations and fancies of the Maori mind. The only weak points are the comparisons of Polynesian names with those of the ancient world. These entirely fail when the words are traced by strict phonetic law to their cognates in Indonesia and Melanesia.

SIDNEY H. RAY.

[1] Dominion Museum Monographs. No. 1. Some Aspects of Maori Myth and Religion. No. 2. Spiritual and Mental Concepts of the Maori. No. 3. The Astronomical Knowledge of the Maori, Genuine and Empirical: including Data concerning their Systems of Astrogeny, Astrolatry, and Natural Astrology, with Notes on certain other Natural Phenomena. No. 4. The Maori Division of Time. By Elsdon Best. Wellington (New Zealand), 1922.

The Promotion of Research in the University of Bristol.

IT is common knowledge that the universities of Great Britain are woefully lacking in funds specifically allocated to the furtherance of their main function, namely, research. Too much prominence cannot, therefore, be given to the activities of the Colston Research Society in the city of Bristol, the object of which is the promotion of research in its University. This Society, under a slightly different name, was originally founded in 1899 for the purpose of promoting the cause of a university at Bristol, and it played a most influential part in securing the foundation of the University ten years later. It then turned its attention to the assistance of a specific branch of university activity and chose that of the promotion of research.

The Society met for its annual dinner and collection on June 1 under the presidency of Mr. Claude B. Fry, with Prof. Flinders Petrie and Sir Richard Gregory as the principal guests. The collection, which amounted to 669*l*., brought the total sum collected since its inauguration twenty-three years ago up to nearly 12,000*l*.

The annual sum of about 600*l*., which is thus available for research, is allocated to the various departments of the University of Bristol by a joint committee of the Society and the University. It is interesting to note that, while the greater part of the funds collected is provided by local merchants and industrial firms, the Society accepts the term research in its widest sense and has recently made awards to the arts faculty, which will be continued so far as funds permit.

In addition to the collection, an important extension in the activities of the Society was made by the president for last year, Mr. Ernest Walls, which seems likely more and more as years go on to cement the relationship between the University and local industries. This act was the foundation of a number of annual Colston research fellowships. These fellowships are post-graduate in character and are earmarked to a particular faculty or branch of research, or to a particular research problem. In those cases in which the research problem is of an industrial character and carried out, with the consent of the supervising professor, at the wish of the firm, additional funds for apparatus and material are also available. The donor of a fellowship has access to the research work and receives the results of the work twelve months prior to publication. During last year fellowships were provided by the Imperial Tobacco Co. (botany), Messrs. J. S. Fry and Sons (engineering), Christopher Thomas Bros. (chemistry), Messrs. Packer and Sons (chemistry), Mr. Frank Cowlin (medicine), and Messrs. E. S. and A. Robinson (chemistry). That the scheme is an undoubted success is borne out by the fact that at the recent meeting of the Society it was stated that five of the above fellowships were being renewed for a second year and that two new fellowships had been promised, one from Messrs. Carsons, Ltd., and the other from Messrs. William Butler, both in chemistry.

To those conversant with the relations between universities and industry in a country like the United States, this may seem to be a very small organisation; but in the present depressed state of the finances of British universities, the existence of one Society rallying to the support of the most essential function of a university is exceedingly encouraging, and the scheme may be commended to the notice of other centres of learning.

Radiation Theory.

ON Monday, May 28, a lecture was delivered at the University of Edinburgh by Prof. H. A. Lorentz, of the University of Haarlem, on "Primary and Secondary Radiation." In the course of his remarks, Prof. Lorentz said that in former times the radiation of light was held to be due to the presence in the luminous source of small particles vibrating about positions of equilibrium; in the electromagnetic theory of light this idea became more definite, in that the oscillating particles were supposed to be electrically charged. The progress made in the last few years has shown that, in many cases at least, this explanation of radiation can no longer be maintained.

In Bohr's theory of spectral lines, the emission of light is due to the transition from one stationary state of an atom to another. The frequency of the emitted radiation is determined by the change in the energy of the atom, and is widely different from the frequency really existing in the atom, in which the electrons freely revolve around the nucleus. When light is emitted by a luminous body, and, in general, when we are concerned with the original production of waves, we can speak of a *primary* radiation, whereas the term *secondary* radiation can be applied to those cases in which particles that are struck by incident rays thereby become centres of emission.

There is perhaps but one case of primary radiation for which the old theory still holds, namely, the emission of electromagnetic waves by an antenna. If, as has been shown by the experiments of Tolman and Stewart, an electric current in a metallic wire consists of a motion of electrons, then this must also be true of the alternating currents in the antenna, so that here the oscillatory motion of the electrons is seen to produce waves.

As to the secondary radiation, this appears in many cases to conform to the classical laws. This can be illustrated by the consideration of (1) Huygens' principle and his construction for the progression of a wave front, (2) the propagation of light in a system of molecules, (3) the scattering of light by molecules (blue of the sky, Lord Rayleigh's formula), (4) the scattering of X-rays (Barkla's experiments), (5) the diffraction of X-rays by crystals, it being possible, as has been shown by W. L. Bragg and Bosanquet, to calculate in this case the intensity of the secondary beams by means of the old theory.

Even for the primary radiation of light, the classical theories need not wholly be abandoned.

Soil Acidity and Plant Distribution.

AN important series of studies on the hydrogen ion concentration of the soil and its relation to plant distribution has been published by Carsten Olsen (*Compt. rend. Lab. Carlsberg*, xv., 1923). These studies deal with the hydrogen ion concentrations of a series of Danish soils covered by natural vegetation, the observed range being from P_H 3·4 to 8·0. The composition of the vegetation is found to be very closely correlated with the hydrogen ion concentration of the soil, and the author considers that the distribution of the more important species may be largely determined by this factor. The number and density of species in a given place are also found to be greatest when the soil reaction approaches neutrality. Olsen further points out that the vegetation of alkaline soils poor in mineral nutrients bears no resemblance to that of very acid soils poor in nutrients. This section of the paper is very impressive in its wealth of data, and it includes exhaustive tables showing vegetation composition in relation to P_H and also a large number of partial soil analyses. Only those who have used the field methods employed by Olsen can really appreciate the extent and thoroughness of his investigations.

The author then deals with the growth of typical indicator species in water cultures. Species normally growing on acid soils are found to show best growth in nutrient solutions with a reaction of about P_H 4·0. On the other hand, plants normally growing on neutral or alkaline soils show most vigorous growth in culture media of about P_H 6 to 7. In these media the plants of acid soils do not thrive and become chlorotic. Olsen further examines the theory of Hartwell and Pember that soil acidity may be associated with the toxicity of aluminium ions. Though aluminium was found to be toxic to barley, the theory appeared not to be valid for plants of alkaline soils in general. Further, while his observations confirm the idea that acid soils as a whole produce ammonia rather than nitrates, Olsen's experiments show no evidence for the supposition that the plants normally growing on acid soils utilise ammonia and not nitrates, or that the plants of alkaline soils can only utilise nitrates. Both nitrates and ammonia appear to have the same value as sources of nitrogen in the cases examined, and, moreover, nitrification may be much more active in acid soils than is commonly supposed, as rapid nitrification existed in soils as acid as P_H 4·4.

This valuable paper should be in the hands of all those interested in soil acidity and plant growth.

University and Educational Intelligence.

BIRMINGHAM.—The late Elizabeth Kenway of Moseley has left to the University a legacy of 1000*l*., free of duty, to be applied as the Council shall think fit.

We learn from the *Times* that the late Joseph Samuel Taylor, of the firm of Taylor and Challen, engineers, has left the residue of his estate, after numerous bequests to local charities, to the University for research work in mechanical engineering, metallurgy, and chemistry.

CAMBRIDGE.—In connexion with the coming meeting of the International Union of Pure and Applied Chemistry, it is proposed to confer honorary degrees of Doctor of Science on M. A. Haller, president of the Academy of Sciences of the Institute of France, Prof. W. D. Bancroft, Cornell University, Prof. E. J. Cohen, University of Utrecht, Prof. C. Moureu, Collège de France, Prof. R. Nasini, University of Pisa, Prof. A. Pictet, University of Geneva, and Prof. F. Swarts, University of Ghent.

Mr. J. E. Littlewood, Trinity College, has been reappointed Cayley lecturer in mathematics; Mr. R. A. Herman, Trinity College, has been reappointed University lecturer in mathematics, and Mr. J. Gray, King's College, has been re-elected Balfour student.

It is recommended that a special grant of 25*l*. be made to the Marine Biological Station at Plymouth.

MANCHESTER.—The Sheridan Delépine research fellowship in preventive medicine, value 300*l*. for one year, will be awarded shortly. The elected candidate will be required to register as a research student of the University, and to devote the whole of his time to research in the department of bacteriology and preventive medicine. Applications, together with particulars of the qualifications of the candidates and of the proposed subject of research, should reach the Internal Registrar on or before June 15.

ST. ANDREWS.—The Court has agreed to hold in trust a sum raised in recognition of Dr. David McEwan's services as professor of surgery in Dundee. The income from the fund is to be employed in providing an annual prize in surgery to be awarded to the best student in that subject in the Final M.B., Ch.B. Examination in the University.

It is expected that Mr. Rudyard Kipling, Rector of the University, will be installed and will deliver his rectorial address on Tuesday, October 9.

THE summer meeting of the Association of Women Science Teachers will be held at Reading, on Saturday, July 7.

NOTICE is given that applications for the Ramsay Memorial fellowships in chemical science, of the value of 300*l*. a year each, must be made not later than June 15 to Dr. Walter Seton, secretary of the Ramsay Memorial Fellowships Trust, at University College, London, W.C.1, from whom full particulars of the conditions governing the award can be obtained.

APPLICATIONS are invited from Edinburgh University medical women for the Dr. Jessie Macgregor prize of 50*l*. for the best piece of original work, published or unpublished, in the science of medicine. Competitors must lodge the record of their work, accompanied by a letter vouching that the work was done by the sender, and mentioning the place or places in which it was carried out, not later than June 30, with the Convener of the Trustees, Royal College of Physicians, Edinburgh.

THE University of Geneva is organising a summer school in which are included two attractive courses of botanical and geological field-work. The botanical course, opening on July 10 and closing on September 10, will be conducted by Prof. R. Chodat, director of the Alpine station at Bourg-St. Pierre in the Grand St. Bernard region, where the course is to be held, and studies will be made of Alpine flora, plant distribution, etc. The geological course will be in the charge of Prof. L. W. Collet, professor of geology in the University of Geneva, and the first portion, July 10-15, will be spent at the University. The remainder of the course, July 16-August 10, will be devoted to field-work on tectonics and glacial geology. Both courses provide opportunities for numerous expeditions. Further information about the courses can be obtained from the Secretary of the University of Geneva, or in Great Britain, from the Economic Division, Swiss Legation, 32 Queen Anne Street, London, W.1.

A STUDY of Dental Education was undertaken early in 1921 on behalf of the Carnegie Foundation for the Advancement of Teaching by Dr. William J. Gies, of Columbia University. Each of the Dental Schools of the United States (47) and Canada (5) has been visited, its equipment thoroughly inspected, and its relationships with other educational institutions ascertained. The investigation has been carried on with the active co-operation of the Dental Educational Council of America and the Canadian Association of Dental Faculties and of the local faculties. The recently published annual report of the Carnegie Foundation announces that Dr. Gies's report will shortly be ready for issue. There being no national board of dental examiners, the examinations for licence to practise in the several States are dissimilar, and the dental laws differ in many of their requirements where uniformity would have obvious advantages. A compilation of these laws, which have not hitherto been easily accessible for comparative study, has been prepared and will shortly be issued with comments on their main educational features. Custom blinds us to the anomaly of the isolation of dentistry as compared with ophthalmology, aural surgery, laryngology, and other specialties of medicine—of putting teeth and jaws in an elaborately insulated compartment by themselves—and a reconsideration of fundamentals such as is likely to be involved in and entailed by Dr. Gies's study may have beneficial results.

Societies and Academies.

LONDON.

Royal Society, May 31.—E. **Griffiths** and G. W. C. **Kaye**: The measurement of thermal conductivity, No. 1. Three types of apparatus of the "plate" type are described for the rapid precision determination of the thermal conductivities of materials at low conductivity. Energy was supplied by electrical means and temperatures were measured by thermocouples. An average time for the attainment of the "steady state" was 30 minutes or less, and the average accuracy of measurement of the conductivity was about 1 per cent. Among the topics discussed was the thermal resistance at the bounding faces of a material, the effect of superimposing layers of compressible material, the measurement of the thickness of compressible material, the dependence of the conductivity of timber on structure and moisture-content and the variation of the conductivity of rubber with mineral content.—G. W. C. **Kaye** and J. K. **Roberts**: The thermal conductivities of metal crystals. I.—Bismuth. A "plate" apparatus measuring thermal conductivities as high as 0·02 C.G.S. with an accuracy of about 1 per cent., using specimens 2 cms. by 1 cm. in area and about 1 or 2 mm. in thickness was used. The conductivities of single crystals of metallic bismuth in directions parallel and perpendicular to the trigonal axis at 18° C. are, in C.G.S. units, 0·0159 and 0·0221. The ratio of conductivities is 1·39. The mean value 0·0191 agrees well with the figure 0·0193 obtained on bars by Jaeger and Diesselhorst in 1899. Thus in the case of bismuth metal in the aggregate, the distribution of the constituent small crystals is random, and the effect on the thermal conductivity of any inter-crystalline layers is not appreciable.—C. V. **Drysdale** and S. **Butterworth**: The distribution of the magnetic field and return current round a submarine cable carrying alternating current. Pt. I. (By C. V. Drysdale.) An exact knowledge of the magnetic field distribution in the neighbourhood of a submarine cable is of great importance in connexion with leader gear and the propagation of radio signals between submerged stations. Investigations have been carried out since 1918 at the Admiralty Experimental Stations at Parkeston Quay and Shandon, with the object of determining the magnitude and phase of the magnetic field in and above the surface, and of the return current in the water, as well as the velocity of propagation and attenuation of the electro-magnetic waves in the water and the shielding effect of the cable armouring. Measurements were made with an alternating current potentiometer on horizontal and vertical search coils above and below the surface and on electrodes in the water at frequencies from 50 to 500 periods per second. Pt. II. (By S. Butterworth.) Expressions for the distribution of electric force due to a long cable carrying alternating currents and immersed in a sea of uniform depth have been obtained in the form of Fourier integrals and formulæ have been developed which cover the following cases: (1) The field above the surface of the sea when the depth of the water is small; (2) the field above the sea at large distances from the cable, there being no restriction in regard to depth; (3) the field below the surface of the sea for points vertically above the cable; and (4) the field below the surface of the sea at large distances from the cable when the depth of the sea is great. The results for points above the surface of the sea have been verified by tests in which the sea is replaced by a sheet of lead. The formulæ are in substantial agreement with actual sea observations.—S. **Russ**: The effect of X-rays of different wave-lengths upon some animal tissues. Two regions in the X-ray spectrum were selected, and it was arranged that equal doses of X-ray energy were absorbed in their passage through the tissues. In these circumstances more profound effects were produced by the longer wave-lengths (0·45-0·30 Å.U.) than by the shorter wave-lengths (about 0·168 Å.U.), both upon the normal skin of the rat and upon Jensen's rat sarcoma. The degree of this differential action is more pronounced in the case of the skin than it is for the tumour, the numerical values being 6 and 2·6 respectively. These numbers are termed "therapeutic factors."—E. F. **Armstrong** and T. P. **Hilditch**: A study of catalytic actions at solid surfaces. Pt. XI. —The action of alumina and certain other oxides in promoting the activity of nickel catalyst. In the absence of any carrier for the nickel, the presence of a small proportion (up to 5 per cent.) of an oxide, such as that of aluminium or magnesium, increases the catalytic activity of the reduced metal. When the nickel oxide is deposited on a support, *e.g.* kieselguhr from which the metallic constituents have been extracted, the catalyst is inferior to that on natural kieselguhr. Its activity is restored if about 20 per cent. of alumina is precipitated with the hydroxide of the nickel. If this proportion of alumina is first deposited on the acid-extracted kieselguhr and the nickel hydroxide or carbonate then precipitated on to this preparation, the catalytic activity of the product generally exceeds that of nickel on the natural kieselguhr. It seems that the action of the non-reducible oxide is mainly mechanical and connected with increase or diminution of the surface area of the exposed nickel.—N. K. **Adam**: The structure of thin films. Pt. IV.—Benzene derivatives.—A condition of stability in monomolecular films. Derivatives of benzene, such as hexadecyl phenol, containing one long chain and one polar group in the para position, orient on water surfaces like fatty acids, the phenol group forming the head of the molecule in contact with the water. Compounds such as cetyl palmitate, palmitic anilide, etc., which contain one polar group placed between two chains or one chain and a ring, do not adhere to a water surface well enough to give measurable condensed films. The para sulphonic acids in hexadecyl and octadecyl benzene give soap-like solutions in water. Pt. V. Bromine in the α position, in the bromo-acids and esters, increases the cross-section of the molecules in the films. The bromine atom increases the solubility of films of the higher fatty acids. It also lowers the temperature of change from condensed to expanded films; but it does not appreciably affect the properties of the films, when expanded. The double linkage in the α β position relative to the $COOC_2H_5$ group increases the cross-section of the molecule in the films, as it does in iso-oleic acid.—W. B. **Rimmer**: The spectrum of ammonia. Of the three bands which are associated with the spectrum of ammonia, the ultra-violet band has already been investigated in detail by Fowler and Gregory, and is represented in the solar spectrum. The "Schuster bands" λ 5635 and λ 5670, have given no sign of resolution under high dispersion, and it is probable that they do not occur in the solar spectrum. The "α band" of Eder and Valenta is of great complexity, consisting of about 3000 lines; there is no conclusive evidence that this band occurs either in the solar spectrum or in the spectrum of sunspots. The Schuster bands seem to have their origin in the normal ammonia molecule and the ultra-violet band is probably due to emission from a more stable combination of nitrogen and hydrogen. The α band appears to be associated with a combination of nitrogen and hydrogen of intermediate stability. The occurrence of the ultra-violet band alone in the solar spectrum indicates that only the most stable combination of nitrogen and hydrogen can exist under the conditions that obtain in the reversing layer.

Royal Microscopical Society, May 16.—E. J. Sheppard, vice-president, in the chair.—W. M. **Ames**: Applications of the microscope in the manufacture of rubber. This work falls into two divisions, examination of pigments and examination of microsections of rubber, both of which involve special methods. For work on pigments, particularly when investigating particle size, slides should be prepared by the method of Green so as to ensure uniform distribution of the pigment in one plane. The microscope enables relative particle sizes to be determined with certainty. Owing to the great resiliency of rubber, the preparation of sections sufficiently thin to be examined by transmitted light is difficult. Inorganic pigments if present can be identified, and their distribution studied. Certain organic materials such as fibre, reclaimed rubber, glue, and rubber substitute can also be identified. The behaviour of the sulphur formations in the rubber can be observed as the rubber perishes, and a comparison made between natural and artificial (heat) ageing. The variation, with temperature, of the solubility of sulphur in vulcanised and unvulcanised rubber can also be observed. When rubber under strain is examined, vacua are found between the separate units of sulphur formations, and at the poles of crystalline pigments, but have not been detected in the case of gas-black or zinc oxide. Permanent internal deformation is visible in the rubber after retraction.

Geological Society, May 16.—Prof. W. W. Watts, vice-president, in the chair.—W. B. R. **King**: The Upper Ordovician rocks of the South-Western Berwyn Hills. The district described lies in the south-eastern corner of the 1-inch Ordnance Survey Map, Sheet 136 (Bala). The area is one where the beds strike in a north-easterly and south-westerly direction, with dips nearly vertical. The black graptolitic shale-group is of shallow-water, probably lagoon, origin. The area appears to have been one of shallow water throughout Upper Ordovician times, and actually became land at the end of that period. The gap in the succession occasioned by this uplift was greatest in the south-east, near Welshpool; while the areas on the north (Glyn Ceiriog) and west (Bala) remained under the sea. The shallowing of the water in these areas is, however, manifested by the deposition of either gritty beds or oolitic limestones. A new species of Calymene is described from the upper part of the Ashgillian, where it is taken as a local index-fossil.—W. J. **Pugh**: The geology of the district around Corris and Aberllefenni (Merioneth). The succession and structure of an area of about 25 square miles, lying south-east of Cader Idris, are described. The area has been surveyed on the scale of 6 inches to the mile. The rocks are partly Lower Silurian and partly Upper Ordovician in age. The Valentian succession is similar to that described at Machynlleth (O. T. Jones and W. J. Pugh, Q.J.G.S. vol. lxxi. (1915–16), p. 343), and the same classification is retained. It is considered to rest conformably upon the Bala series. The general strike, from south-west to north-east, is determined by the fact that the area lies on the south-eastern flank of the Harlech Dome; but the district is crossed by important folds transverse to the normal strike. These structures have been correlated with those described farther south at Machynlleth.

Aristotelian Society, May 28.—Prof. A. N. Whitehead, president, in the chair.—C. Delisle **Burns**: The contact of minds. The word "mind" is taken to mean mental process or percipient event, and thus to refer to all such facts as thinking, feeling, and the sensation which accompanies or is part of thinking. It is generally admitted that mental processes are grouped so that they "belong to" distinct persons or selves; but there is also a connexion between these groups of mental processes in co-operation or communication or intercourse between persons. In communication "I" am aware that "you" are thinking, that is to say, I am aware that you are or have a mind; or it may be said that I am aware that an "other" mind exists. The problem to be considered, then, is *how* I come to know that an other mind exists. The traditional view is that "I" come to know that other minds exist by a process of inference, based upon a comparison of my "body" with other bodies. This traditional view has already been attacked by Lossky and others. It seems false, first, because it implies a very unlikely description of psychological development. Secondly, at any stage in life the differences between my own body and other bodies in my contemplation are so great that the likeness can scarcely be a valid logical ground for the belief that other minds exist. As an alternative to the traditional view, therefore, it is suggested that Prof. Alexander's term "enjoyment" may provide an explanation of the way in which "other" minds come to be known. But enjoyment must then be taken *not* to imply any process peculiar to "my" thinking or feeling. That is to say, there must be enjoyment of co-operation or communication. As objects are given in contemplation, so other minds are given in another form of awareness. There is, then, direct contact of minds, not "through" bodies or across any bridge which is non-mental. This, however, does not mean that mind is not bodily; since mental process is probably the name for a relation, the terms of which are bodily. We need not assume that mental process is explicable in terms of "body" or that "body" is explicable in terms of mental process: but the contact of minds occurs in one area of reality and the contact of bodies in another, and the two are inseparable, as the force called gravitation is inseparable from "mass."

DUBLIN.

Royal Irish Academy, May 14.—Prof. Sydney Young, president, in the chair.—J. J. **Nolan** and J. **Enright**: Experiments on large ions in air. The effects of such substances as sulphur dioxide and ammonia on the development of large ions were investigated. The effect of temperature on the large ions was examined. The large ion is unaffected up to 100° C., but at that temperature begins to break up. The coefficient of recombination between large and small ions was determined. The conditions under which multiple charges on the large ion can occur were investigated. The large ion in the atmosphere has probably a single electronic charge.

EDINBURGH.

Royal Society, May 7.—Prof. F. O. Bower, president, in the chair.—Miss A. V. **Douglas**: The sizes of particles in certain pelagic deposits. Samples of sea bottom brought back by the *Quest* from the South Atlantic bottoms were examined for the distribution of sizes of particles. The estimation is made by allowing continuous deposit of the particles from suspension in water upon one pan of a balance and thence ascertaining the rate of deposit and estimating the associated sizes, employing Stokes's law. The result is a measure of relative numbers of particles of each equivalent spherical radius. Six samples are treated, three of diatomaceous ooze, and three of globigerina ooze. The features of the curves showing proportionate distribution of sizes confirm the characters formed by Sven Odén from the *Challenger* specimens.—R. A. **Houstoun** and W. H. **Manson**: Note on a new method of investigating colour blindness. In a previous paper Dr. Houstoun investigated 23 cases of congenital colour blindness and exhibited the results by contour lines on the colour triangle. The same method has been applied to 14 cases of colour blindness induced by disease. The results show that there is no difference in kind between the two classes of cases, and that here also trichromasy passes into monochromasy directly without passing through dichromasy as an intermediate case.—W. **Peddie**: The mechanism behind relativity. The Lorentzian equations of transformation from one reference frame to another were introduced in order that Maxwell's equations of propagation of electromagnetic action should be invariant in form under the transformation. Besides this explicit assumption, there is, further, the implicit postulate of a single unique luminiferous ether through which action is propagated at a constant (or approximately constant) speed. The theory of relativity was originated by the latter postulate as much as by the former. The compulsion to adopt Lorentzian relativity disappears if we postulate instead that each atom of matter is associated with a strain form (in an underlying ether) through which alone it receives light, and that it emits light into the similar strain forms of other atoms. The Michelson-Morley result, the aberrational effect, the Fresnel dragging coefficient, and the Doppler effect, all follow; and only the Newtonian relativity is employed, for light is propagated independently to each observer.—R. A. **Sampson**: On Lorentz's equations and the concepts of motion. This paper is a mathematical examination of the foundations of Lorentz's equations, with special reference to the time paradoxes which it is well known that they imply. As a result a group or family of similar equations emerges, among which Lorentz's form occupies a peculiar place. Other members of the family introduce no paradoxes and are equally competent to explain all the known critical experiments.—J. **Marshall**: The interior and exterior space-time forms of the Poincaré electron in Weyl's geometry. Forms for ds^2 are obtained from Weyl's gauging equation. Assuming $g_{14}=0$, the value of $\phi\mu$ is obtained, and arising from the ds^2 form, a pressure is shown to act inwards on the electron.

PARIS.

Academy of Sciences, May 14.—M. Albin Haller in the chair.—C. **Guichard**: The triple orthogonal systems of M. Bianchi. Application to a problem on reciprocal polars with respect to a sphere.—M. de **Sparre**: Concerning hammering in return mains.—J. L. **Walsh**: A theorem of algebra.—René **Garnier**: Uniform functions of two independent variables defined by the inversion of an algebraic system to total differentials of the fourth order.—Georges **Bouligand**: The singularities of harmonic functions.—H. G. **Evans** and H. E. **Bray**: Poisson's formula and the problem of Dirichlet.—J. **Haag**: The resolution of certain equations of Fredholm by means of an integral series.—Max **Morand**: The electromagnetic origin of inert mass and heavy mass.—Maurice **Nuyens**: Gravific field due to a massic sphere taking into account the cosmic constant.—Pierre **Steiner**: The ultra-violet absorption spectra of the alkaloids of the isoquinoline group: narceine. The ultra-violet absorption curve of narceine resembles generally that of narcotine and of opianic acid. The curve of hydrocotarnine is different from the preceding. So little as 0·05 milligrams of narceine in 2 c.c. of solvent can be detected spectrographically.—A. **Dauvillier**: High frequency spectrographic researches in the group of the rare earths. The results of a detailed examination of the L series of cerium, neodymium, samarium, europium, and gadolinium.—M. S. **Lambert**: Stereoradioscopy.—F. **Wolfers**: An appearance of reflection of X-rays at the surface of bodies.—Hector **Pécheux**: The magnetism of steels. An account of measurements made with three steels of varying carbon content. For forged annealed steels the permeability decreases with increase of carbon.—G. **Athanasiu**: The sensibility of photographic plates containing mercury salts. Of the mercury salts studied, the plates with mercuric iodide were the most sensitive, with a maximum in the green, the sensibility decreasing rapidly and uniformly with the wave-length. Curves are given showing the relation between the sensibility and the wave-length for mercuric and mercurous iodides, mercurous bromide, and chloride.—P. **Laffitte**: The formation of the explosive wave. A study of the explosion of carbon bisulphide and oxygen, utilising the photographic method of Mallard and Le Chatelier.—Alfred **Marx** and Jean **Rozières**: The purification of liquids by the simultaneous action of centrifugal force and the electric field. The removal of colloidal matters in suspension from liquids has been attempted by centrifugal force and by electrical fields, but neither method has completely solved the problem on the industrial scale. The use of an electro-centrifugal separator (2700 turns per minute, voltage gradient 4000 volts per centimetre), has proved successful with dirty transformer oil, the breaking down voltage being increased from 19,000 to 31,000 volts. This material remained practically unchanged when rotated at the same speed without an electrical field; the latter, without rotation, also proved ineffective.—Paul **Pascal**: The preparation of sodium metaphosphate at a low temperature. By the interaction of sodium ethylate and ethyl metaphosphate, sodium metaphosphate is produced at a temperature between 35° and 40° C. Its cryoscopic behaviour proves this salt to have the formula $NaPO_3$, differing from the polymers previously known. The salt may be heated to 800° C. without polymerisation.—**Pastureau** and H. **Bernard**: Tetramethylglycerol. The chlorhydrin $(CH_3)_2 . C(OH) . CHCl . C(OH)(CH_3)_2$, the mode of preparation of which has already been described by the authors, on treatment with an aqueous solution of potassium carbonate gives tetramethylglycerol.—Alfred **Gillet**: A verification of the antioxygen power of the polyphenols: relation between the fastness to light of dyes on the fibre and the presence in their molecule of the diphenol function (ortho- or para-). With the exception of pyrazolone dyes and cotton fabrics dyed with a copper mordant, great stability of dyes on fibre is closely related to the presence in the molecule of an *o*- or *p*- diphenol group.—Ph. **Schereschewsky** and Ph. **Wehrle**: The study of clouds by synoptic photography (the cloud week).—J. **Houdas**: The preservation of seeds in inert gases. Certain seeds (such as *Geubera Jamesoni*) lose their germinating power after exposure to air for a few weeks. In sealed tubes in an inert gas (hydrogen or carbon dioxide) the germinating power of seeds of this plant has been proved to be unchanged after eleven years. The seeds of other plants have given similar results.—L. J. **Simon**: The determination of carbon in arable soil. The method of wet combustion with silver bichromate is recommended.—J. M. **Lahy**: The graphical study of the stroke in typewriting. The speed of typewriting is a function of the alternation of the hands. No general rule can be given as to the number of fingers to be used; the touch is personal, and the most favourable mode of working can only be obtained by study of the individual.—Auguste **Lumière**: The toxicity of autolysates and of tissue extracts.—J. **Lopez-Lomba**: Changes in weight of the organs of the pigeon in the course of B-avitaminosis. The changes of weight in ten isolated organs of the pigeon fed with a diet deficient in B-vitamins are shown graphically.—**Samec** and V. **Isajevič**: The composition of glycogen. A comparison of the properties of starch and glycogen. There are various points of difference, the most marked being the higher proportion of phosphorus in the glycogen.—J. **Voicu**: The effect of humus in small and larger doses on the fixation of nitrogen by *Azobacter chroococcum*.—Alphonse **Labbé**: The influence of the increasing P_H of sea-water on the rapidity of segmentation of the eggs of Halosydna and Sabellaria.—Robert **Dollfus**: The trematode of mother-of-pearl in Provence mussels.—Foveau de **Courmelles**: The similitude of forms of shock in medicine, their dangerous but avoidable superposition. A discussion of anaphylactic shock produced by X-ray treatment, and means of avoiding it.

CAPE TOWN.

Royal Society of South Africa, April 18.—Dr. A. Ogg, president, in the chair.—C. von **Bonde**: Note on the Heterosomata (flat-fishes) of South Africa. Some abnormalities are discussed which are occasionally found in pigmentation, scales, etc., of flat-fish generally, and in particular in some new species described.—T. **Stewart**: Some notes on the drought of 1922–23 on Table Mountain. The first rainfall observations on Table Mountain were begun in January, 1881, when a gauge was placed at a spot called Disa Head, the elevation of which, above the sea-level, is about 2500 feet. Additional gauges were fixed, until by the year 1900 there were eleven in all. The average rainfall for 30 years on the highest portion of the mountain is about 75 inches. The average for the same gauges for 1922 was about 66¼ inches, and there were ten years of the 30 when the average was lower. On no previous dry season has the precipitation at Waai Kopje (elevation 3100 feet)—which gives results for 42 years—been so low as it has been for the seven months, September-March, 1923. If the Disa Head station is taken as indicating the conditions at the 2500 feet level, the dry seasons of 1883–84, 1919–20, and 1920–21 were drier than the last one.—J. S. **Thomas**: The sulphide and hydrosulphide of ammonium. By the action of hydrogen sulphide on alcoholic solutions of ammonia at 0° C., solutions were obtained in which the ratio $[NH_3]/[H_2S]$ approximated to 1; *i.e.* the solution consisted mainly of ammonium hydrosulphide. Ammonia reacts with ammonium hydrosulphide suspended in ether extremely slowly, but on the addition of a small quantity of alcohol a rapid reaction takes place and a heavy yellow oil separates, having the composition $(NH_4)_2S_2NH_3$. This substance is very unstable, and is extremely toxic. When this oil is allowed to stand, transparent cubic crystals separate for which the ratio $[NH_3]/[H_2S]$ was found to be 2. This substance appears to be anhydrous ammonium monosulphide.

Official Publications Received.

Annales de l'Institut de Physique du Globe de l'Université de Paris, et du Bureau Central de Magnétisme terrestre. Publiées par les soins de Ch. Maurain. Tome Premier. Pp. 323. (Paris: Les Presses universitaires de France.) 75 francs.

Scientific Papers of the Bureau of Standards. No. 465: Composition, Purification, and Certain Constants of Ammonia. By E. C. McKelvy and C. S. Taylor. Pp. 655-693. 10 cents. No. 466: Wave Length Measurements in the Arc Spectra of Gadolinium and Dysprosium. By C. C. Kiess. Pp. 695-706. 5 cents. (Washington: Government Printing Office.)

Annual Report of the Zoological Society of Scotland for the Year ending 31st March 1923. Pp. 24+8 plates. (Edinburgh.)

Ministry of Public Works, Egypt: Physical Department. Meteorological Report for the Year 1918. Pp. x+136. (Cairo: Government Publications Office.) P.T. 30.

County Borough of Eastbourne. Annual Report of the Meteorological Observations for the Year 1922. Pp. 24. (Eastbourne.)

Diary of Societies.

SATURDAY, JUNE 9.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Dr. A. W. Hill: The New Zealand Flora.

MONDAY, JUNE 11.

VICTORIA INSTITUTE (at Central Hall, Westminster), at 4.30.—E. W. Maunder: The Two Sources of Knowledge: Revelation and Science (Annual Address).

TUESDAY, JUNE 12.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Prof. J. B. Leathes: The Rôle of Fats in Vital Phenomena. (Croonian Lectures (2).)

ZOOLOGICAL SOCIETY OF LONDON, at 5.30.—R. Broom: The Structure of the Skull in the Carnivorous Dinocephalian Reptiles.—N. A. Mackintosh: The Chondrocranium of the Teleostean Fish *Sebastes marinus*.—R. I. Pocock: The External Characters of Pigmy the Hippopotamus (*Chœropsis liberiensis*) and the Suidæ and Camelidæ.—Major E. E. Austen: A Revision of the Family Pantophthalmidæ (Diptera), with Descriptions of new Species and a new Genus.—R. Dart and Dr. C. W. Andrews: The Brain of the Zeuglodontidæ (Cetacea), with a Note on the Skulls from which the Endocranial Casts were taken.—O. Thomas and M. A. C. Hinton: Mammals collected by Capt. Shortridge during the Percy Sladen and Kaffrarian Expedition to Orange River.

BRITISH PSYCHOLOGICAL SOCIETY (Education Section) (at London Day Training College), at 6.—Dr. P. B. Ballard: The Validity of certain New Methods of Testing.

QUEKETT MICROSCOPICAL CLUB, at 7.30.—J. Burton: Notes on Fixing, Staining, and Mounting Freshwater Algæ.—Secretary: Notes on Mounting and Report of Petrographical Interest on the Deposits sent by Mr. Hamm to the Club.—J. H. Barton: Demonstration of a New Form of Microscope.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Rev. W. H. Leembrugger: Social Transitions among the Natives of New Georgia, Solomon Islands.

THURSDAY, JUNE 14.

ROYAL SOCIETY, at 4.30.—Dr. C. Chree: Magnetic Phenomena in the Region of the South Magnetic Pole.—O. R. Howell: The Catalytic Decomposition of Sodium Hypochlorite by Cobalt Peroxide.—Nina M. Hosali: The Seismic Waves in a Visco-Elastic Earth.—J. W. Landon and H. Quinney: Experiments with the Hopkinson Pressure Bar.—S. F. Grace: Free Motion of a Sphere in a Rotating Liquid at Right Angles to the Axis of Rotation.—B. F. J. Schonland: The Passage of Cathode Rays through Matter.

ROYAL COLLEGE OF PHYSICIANS OF LONDON, at 5.—Prof. J. B. Leathes: The Rôle of Fats in Vital Phenomena. (Croonian Lectures (3.))

OPTICAL SOCIETY (at Imperial College of Science and Technology), at 7.30.—S. G. Starling: Levels and Level Bubbles.—T. F. Connolly: A New Form of Balloon Theodolite.—E. W. Taylor: The Primary and Secondary Image Curves formed by a Thin Achromatic Object Glass with the Object Plane at Infinity.

CHEMICAL SOCIETY, at 8.30.—Prof. C. Moureu: Les gaz rares des sources thermales, des grisous et autres gaz naturels (Lecture).

ROYAL SOCIETY OF MEDICINE (Neurology Section), at 8.30.—Dr. L. R. Yealland: Hysterical Fits, with some reference to their Treatment.

FRIDAY, JUNE 15.

ROYAL SOCIETY OF ARTS (Indian Section), at 4.30.—Sir John H. Marshall: The Influence of Race on Early Indian Art (Sir George Birdwood Lecture).

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—Mr. and Mrs. D. E. Batty: A Simplified Method of Printing in the Gum-Bichromate Process (with a Demonstration).

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir Ernest Rutherford: The Life History of an Alpha Particle from Radium.

SATURDAY, JUNE 16.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir Ernest Rutherford: Atomic Projectiles and their Properties (VI.).

PUBLIC LECTURES.

MONDAY, JUNE 11.

UNIVERSITY COLLEGE, at 5.—N. Fryer: Unknown Central Europe.

TUESDAY, JUNE 12.

ST. BARTHOLOMEW'S HOSPITAL MEDICAL COLLEGE, at 5.—Dr. A. Balfour: Tropical Hygiene. (Succeeding Lectures on June 14, 19, and 21.)

WEDNESDAY, JUNE 13.

UNIVERSITY COLLEGE, at 5.30.—J. C. Gröndahl: Norwegian Literature of the Present Day.

THURSDAY, JUNE 14.

ST. MARY'S HOSPITAL (Institute of Pathology and Research), at 4.30.—Prof. G. Dreyer: Some New Principles in Bacterial Immunity and their application to the Treatment of Refractory Infection.

New Methods of Crystal Analysis and their Bearing on Pure and Applied Science.[1]

By Sir William Bragg, K.B.E., F.R.S.

It is one of the most fascinating of all studies to trace back the properties of the substances that we see round about us to the manner and the details of their underlying structure. There are in the world, or indeed the universe, a certain number of different kinds of the atoms of which all things are made. We know of rather more than ninety in all. The science of radioactivity has brought to our notice atoms distinguished by special powers of emitting radiations, but the list is not really increased thereby. Everything we see round about us, or are aware of when perhaps we cannot see, is built up by joining together these atoms in various ways: and all the properties of substances, their infinite complications, powers, and beauties, are associated with the properties of the atoms even before construction is begun. It is surely no wonder that we try to find out how this is done.

Chemistry itself has its origin in this quest. One of its early successes was the explanation—incomplete, no doubt—of the part played by oxygen in the act of burning or rusting. As chemistry has grown to its present magnitude all its findings have related to the part played by this or that atom or combination of atoms in determining the properties of various substances. The methods of chemistry are founded on the study of the behaviour of crowds. The smallest portion of any substance handled in the laboratory contains billions of atoms; and the properties of the individual are inferred from the treatment of gross aggregates. The chemist mixes together two liquids in certain proportions, observes, tests, and weighs the results; and he infers that atoms already grouped in certain combinations are ready to change to fresh groupings. From his weighings he finds the proportions in which the atoms break with one another and recombine. He observes and measures their readiness to change partners. Sometimes the exchange is so rapid that energy is liberated with explosive violence. Sometimes it is so slow that it must be hurried, either by the application of warmth or by other means, the quaintest of which is the action of a catalyst, a third body which promotes a new grouping without being finally concerned in it; as the chaperone of bygone days effected the introduction between two people anxious to meet each other and then effaced herself.

The science of radioactivity takes up the study of the atom in a totally different way. It finds that sometimes atoms are endowed with movement so rapid that the individual has enough energy to make its own mark. In the spinthariscope of twenty-five years ago Sir William Crookes showed the separate and visible flashes which were made when a succession of helium atoms, shot out from radium, struck a phosphorescent screen. Each impact made its little flash of light just as when a pebble is dropped at night into a phosphorescent sea. This is a typical experiment belonging to the science of radioactivity, typical in that it deals with the individual and not with the crowd. In this science there is very little concern with the combinations of atoms. It leads more to a study of the nature of the internal structure of the atom: that is why if we wish to understand the atom's inner mechanism we turn to the work which J. J. Thomson, Rutherford, Aston, and others are doing. The new methods with which I deal here attack the question from yet another aspect, based on the recognition of the properties of crystals on one hand and of X-rays on the other.

A crystal that has grown without disturbance presents surfaces of brilliant polish which make with each other angles of characteristic and invariable magnitude. Sometimes one face grows abnormally as compared to others, on account, it may be, of some disposing cause in the circumstances in which the crystal was formed, but in crystals of the same substance the angles between corresponding faces are always exactly the same. There are not, usually, many different kinds of faces on a crystal. Often on careful examination it is found that there are not more than three or four. If we examine specimens of the same crystal which seem at first sight to differ in form, we find that the difference is nothing more than an unequal development of the various types of face. An outward presentment so simple as this must imply a like simplicity in internal design. There must be a unit of pattern which contains but few atoms and, repeated again and again through space, makes up the whole crystal. The idea has long been familiar to the crystallographer, but he could not push the corresponding interpretation to its limits: he had no clue to guide him, no methods of examining the actual details of the design. The reason of the failure is not difficult to understand: the details were too fine to be distinguished under the most powerful microscope. Nor is this a mere question of a lack of technical skill which might be removed at some future time. It will never be possible to see the arrangements of atoms in a crystal.

When we say that we see any particular thing, what we really do is to observe some change which the thing has made in the light waves which reach our eyes after they have been reflected or scattered or in

[1] Sixth Trueman Wood Lecture, delivered at the Royal Society of Arts on January 24.

some other way affected by the thing that is seen. This means that the thing itself must be comparable in size with the wave-length of light. We could not expect to gather from the behaviour of a breaker as it rushed up the beach information as to the size and form of the individual grains of sand over which it had passed. We might expect, however, to be able to gather information as to the extent of a reef from observation of the degree to which it had stilled the waves that traversed it before they reached the shore. Now, the diameter of an atom is quite a thousand times less than the length of the light-waves which affect our eyes. Consequently it is out of the question that we should ever see it in the sense that we can see small objects even under the microscope. A very simple way to realise this point is to consider that the atoms form part of the very lenses of the microscope; and, if we tried to increase our power of microscopic vision by redesigning the optical arrangement, the lenses would have become, so to speak, granular and have lost their optical properties long before we were able to "see atoms by their aid." The fact is that light-waves are adapted for ordinary seeing, and that by the microscope we have stretched their proper range some thousands of times. Nothing that we can ever do with ordinary light will give us the magnification of a hundred million times, which is what we require if we are to study the atoms themselves. We want a new sort of light of immensely finer quality than ordinary light; and we have been fortunate enough to find this in the X-rays. X-rays are simply a form of light the wave-length of which is ten thousand times shorter than that of the light with which we see in the normal way.

There is one more point to be made clear before we can realise how the combination of X-rays and the crystal has opened up a new vista. Although the X-ray is so fine in structure that it can really be affected by the individual atom, the magnitude of that effect is too small to be of any use: it is here that the crystal helps us. We remember that there is in the crystal a perfectly regular repetition of some simple pattern or combination of atoms. When X-rays sweep over them, whatever effect one of the units has, all its fellows have also; and so on the whole there is a combined action big enough in its results to be detected by instruments designed for the purpose. In somewhat the same way, to take an example, each tiny furrow on a piece of mother-of-pearl is of the right order of width to have an effect on the light which is reflected by the whole piece, but the magnitude of one such effect is not enough to make an impression on our eyes. However, on the surface of the pearl there are many thousands of such furrows very like one another and running more or less in the same direction, and what one furrow does the others do also. It is this combined or multiplied action which so affects the light as to give the beautiful play of colour associated with mother-of-pearl.

Now we have all the factors essential to the new methods: the X-rays for fineness of vision and the crystal for combination in the action of the atoms upon the X-rays. It is not necessary now to go into further details; it is only needful to realise that there is an instrument called the X-ray spectrometer in which the reaction between the X-rays and the atomic arrangements enables us to study the form and size and disposition or structure of the atomic patterns of the crystal.

Every crystal is in a way a long avenue down which we can look and see at the far end of it the most primitive groupings of the atoms. The wonder is that we should be able to look so far, that the structure of the crystal should be so finished and so unvarying from first to last that our observation of a crystal big enough to handle should tell us no more and no less than the properties of the one little unit of pattern. If the diamond in a ring were increased to the size of the earth the individual carbon atoms would only be about as big as tennis balls. Yet so faithful is the information which X-rays and crystals give us that we can compare, and indeed measure, the distances from atom to atom with an error less than 1 part in 1000. This new power, which is surely wonderful enough, we naturally apply to the further elucidation of the problem which I described at the beginning. We try to find out, by fresh means, the relations between the properties of substances and the nature of the atomic structures of which they consist.

It might be objected that a crystal is something special and that most bodies do not show the perfect crystalline form. The difficulty is apparent, not real. In the first place, far more substances are crystalline than would be supposed, and actually every substance would more naturally develop into a perfect and characteristic crystal than into any other form. The crystal is the natural condition. Bodies which seem to us to present no crystalline appearance at all are often aggregates of minute crystals jammed together miscellaneously or held like a mush in a semi-liquid matrix. Often, again, as in the case of liquids, the various atoms and molecules have not had time nor peace enough to arrange themselves as they would. Even if many of the substances in the behaviour of which we are most interested, such as iron and steel, are far in form from the perfect crystal, yet we may expect to arrive in the end at an understanding of their structure by the separate examination of the few definite forms of crystal of which, as we know well, the whole mixed mass is compounded.

We may now go on to consider individual cases. It is, perhaps, natural to a new form of inquiry to deal with particular instances of its application as they have been so far made, rather than to attempt broad generalisations. As we consider each case let us look at it from the point of view already emphasised. Let us try to see how the properties of the whole crystal depend strictly upon and are, indeed, an index to the properties of the atoms and atomic combinations of which it is made.

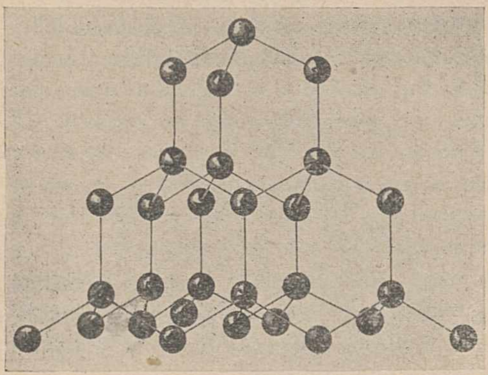


FIG. 1.—Diamond; showing how each carbon atom, represented—only diagrammatically—by a black ball, lies at the centre of gravity of its four nearest neighbours.

The diamond is, perhaps, the best to begin with. Its unique qualities dispose us to expect a structure which is equally distinguished, and so it turns out to be. The structure is figured in the accompanying sketch (Fig. 1). It may look at first sight somewhat complicated, but when it is examined closely it is found that the whole story is told in one sentence. Each atom has four neighbours regularly disposed about it. In other words, the four make a regular tetrahedron, and the first atom is at the centre of it. In the arrangement so determined by X-ray analysis we recognise at once an agreement with one of the most important deductions of the chemist, the so-called tetravalency of the carbon atom, which means a tendency to associate itself with its neighbours by four bonds of equal strength. The hardness and strength of the diamond are based on the simplicity and regularity of this tetrahedron arrangement, and in addition on the strength of the tie between atom and atom. We find that atoms are fastened together by bonds of two or three different types; the one here illustrated is the strongest of all. Every atom, we know nowadays, consists of a central core, which is positively electrified, and of a sufficient number of negative bodies of a second kind called electrons to balance the positive charge on the core. The diamond is an example of many cases where neighbouring atoms share electrons and build them each into their own structure. It is somewhat analogous to the sharing of party-walls by the houses of a terrace. Yet it can be seen that the structure is obviously weaker in certain directions than in others. Such are the horizontal planes in the figure. These are called the cleavage planes. The diamond-worker takes advantage of the fact, using it skilfully instead of grinding. An excellent example is to be found in the exhibit of the Crown Jewels in the Tower, where the manner of cleaving one of the great diamonds is shown. There is a second plane of cleavage, which is only used by workmen of the greatest skill, as it is much more difficult to bring off the operation successfully. It is at right angles to the plane of the first kind. The tetrahedral form of structure is often reproduced in the form of the whole diamond, though no one, I believe, knows exactly why the faces of the tetrahedron are often rounded. This does not mean that the layers of the atoms are curved, but simply that they lie on one another like a series of steps. A structure so tightly bound together is brilliantly clear from the optical point of view.

There is another form of carbon crystal, that of graphite or black lead, the properties of which seem so different from those of the diamond that it is difficult to believe they are of the same element and, moreover, of much the same construction. One common feature is of great interest, namely, the existence in both cases of layers of atoms arranged in hexagonal pattern. It is difficult to express in words, but the illustration (Fig. 2) will make it clear. Each atom is still bound to three of its neighbours by the same strong ties as before, but the fourth is broken and a weaker, lengthier connexion is substituted. All this is reproduced in the outward appearance of graphite. Its crystals are badly formed, but are more or less in hexagonal columns, which split up with the greatest ease into thin leaves at right angles to the column axis. So easy, indeed, is this cleavage that the pounding of a mass of graphite in a mortar is ludicrously ineffective. The leaves simply multiply themselves more and more. One leaf slides on another very easily, yet the atoms in each leaf hold well together. It is the combination

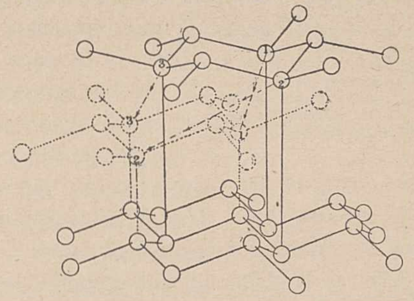


FIG. 2.—The fine lines of the diagram show the structure of graphite. By moving the top layer to the position shown by the broken lines the diamond structure is obtained.

of these qualities that gives to graphite its lubricating powers. If you slip on the black-leaded hearthstone, it is because some of the layers which are sticking to the sole of your shoe slide on others which cling to the stone. I do not know that you can find a better example of the relation between the external features of a crystal and its elementary structure. One change has converted the hard diamond into the soft, slipping graphite, and it is easy to see that the results are exactly what one would expect from the nature of the change.

Now we may pass on to another structure which is much like that of the diamond, namely, that of ice (Fig. 3). The fundamental element of the design is again the fact that an atom, oxygen in this case, is surrounded symmetrically by four other atoms of like kind; the latter making a regular tetrahedron of which the former is the centre. But there is this difference between diamond and ice: that in the latter case an atom of a second type, namely, hydrogen, is inserted between every pair of oxygen atoms. Thus, the immediate neighbours of each oxygen are four hydrogens. As every hydrogen has only two oxygen atoms as neighbours, there are twice as many hydrogens as oxygens in the structure. That is, of course, in agreement with the known composition of water.

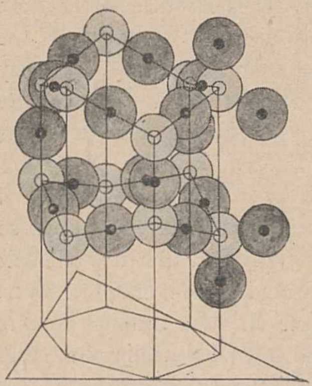


FIG. 3.—Ice. White spheres represent oxygen atoms, and the black spheres hydrogen: enough of each kind are drawn to show the hexagonal nature of the crystal. Each black ball lies between two white: each white touches four blacks, but in two cases only, on the right of the diagram, the full number, four, is put in. The distance between the centres of two neighbouring oxygens is known with accuracy, but it is not known how much of the intervening space is occupied by the hydrogen.

Here, also, as in diamond and graphite, are to be found layers in which the atoms are arranged in a hexagonal pattern. Arctic explorers have described a hexagonal structure in the ice-floes; the block breaking up into hexagonal vertical columns resembling the pillars of the Giant's Causeway. But the most beautiful ice-crystals are found in the snowflakes or in the frost figures on the window. The forms are of an intricate delicacy based always on the hexagon and on the angle of 60°. In the model which is illustrated the foreshadowing of the sixfold symmetry is shown. The featheriness of the snow is the outward expression of the lightness of the pattern, which resembles lace rather than a continuous structure. It is clear that the atoms could be packed more tightly, and that must have something to do with the fact that when ice is compressed it tends to melt. It is not easy to understand why the atoms join together in this of all possible ways. It is evident that particular points in the structure of one atom are linked up with corresponding points in the structure of another. Such considerations have, no doubt, to do with the internal structure of the atoms themselves,

It is a curious fact that when a tetrahedral structure is found, as in the cases of diamond and ice, there is an alternative with respect to one of the details. By a slight structural change somewhat difficult to describe in words, the tetrahedral arrangement of the diamond becomes the usual hexagonal arrangement of ice. Mr. Whipple has directed my attention to a paper written about a hundred years ago, in which the author describes ice-crystals of peculiar form which he had found on the wooden bridge of Queen's College, Cambridge. It is possible to make out from the description that in this case the ice had grown as a diamond would do: the effect is described as one of great beauty and brilliance.

There is one feature of the carbon structures which is of great interest. The hexagonal ring of six atoms is to be found both in diamond and graphite. Now, a whole branch of chemistry of first-rate importance is concerned with the examination of substances of which such a ring forms the essential element of design. When an atom of hydrogen is attached to each atom of carbon the ring with its fringe is the molecule of benzene. The ring is an extraordinarily persistent combination.

Organic chemists have learnt that they can detach at will one or more of the hydrogens, replacing them by somewhat more complicated groups, such as the pair of oxygen and hydrogen atoms called the "hydroxyl group," or the "nitro group," consisting of one nitrogen and two oxygens, and so on. In this way an immense number of different substances are formed of widely varying properties. They occur in the work of the dye chemists, in the manufacture of explosives, in the study of living organisms, and, in fact, constitute a most important class of bodies. Chemists have inferred the existence of these rings by reasoning processes of really wonderful accuracy and power. It is natural to suppose that the ring which we find in our structures is the very ring which has been the concern of the organic chemist.

We have tried to put this idea to the test, and so far, I think, with success. We can measure this ring in the diamond. It is just one hundred millionth of an inch across, and we can make good estimates of the enlargements that must result from such substitutions for the hydrogens as I have already described. We can then measure the space which the rings, modified or not, occupy in the organic crystal, and we get a very satisfactory fit (Fig. 4).

We have, for example, estimated the size and form of the molecules of naphthalene and anthracene on the assumption that they consist, respectively, of two benzene rings, and three benzene rings, in line; in accordance with chemical evidence. We have found, by X-ray analysis, the size and form of the unit cells (Fig. 6); a simple calculation shows that two molecules have to be packed into the cell in each case; the crystals, it should be observed, are isomorphous.

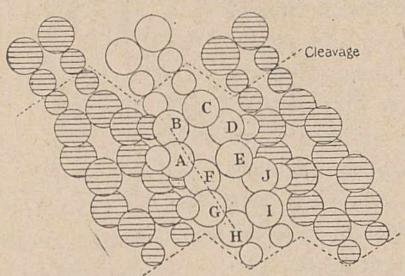


FIG. 4.—Showing mutual relations of three naphthalene molecules and parts of others. Letters are attached to all the carbon atoms of one molecule; hydrogen atoms completing this molecule are attached at A B C D G H I J.

It is found that the molecules pack into place very well, if they are arranged as in the sketch of Fig. 4. The figure refers to naphthalene, but the modification required for anthracene is readily conceived; and, indeed, it appears that the cell in one case is exactly as much longer than in the other as would be expected considering that the anthracene molecule contains one more ring than the naphthalene. Here again we may see in the structure of this little unit of naphthalene, which contains two double rings, everything that foreshadows the properties of the whole crystal. Why is the substance so light? Because the structure is so lace-like and there are so many empty spaces. Why does it break up so easily into thin flakes? Because the molecules lie side by side somewhat like corn bent by the wind, and their side-to-side attachments differ from those that are end to end: the latter break more easily and the substance naturally splits up into layers, each of which is like a velvet pile, the fibres of which represent the molecules. Why does the substance melt so easily? Because *all* the attachments of molecule to molecule are feeble and break up under disturbances due to heat. And so we may go on. If we attach a hydroxyl group to the side of the molecule we see the fibres of the pile open out sideways. If we attach it at the ends, we find the fibres grow longer; the two substances formed in this way are well known in the dye industry.

We have recently been examining the crystalline form of a number of the organic substances, and have learnt something of a very interesting system which governs the packing. It holds for all crystals apparently, but is very plain in the organic field. There are two stages in the process of the formation of the crystal from the original atoms. First of all, the atoms are grouped into companies which the chemist calls "molecules." Chemistry has concerned itself largely with the study of the molecule, and particularly with the molecule in the free state, as in a liquid or a gas. In the second stage the molecules, retaining their composition if not their exact form, are packed together to make the crystal pattern: it is this stage which is the subject of our present considerations, and can be analysed by the X-ray methods. Take a simple example:—Two atoms of hydrogen and one of oxygen make up the water molecule. It is a company of atoms strongly tied together in an alliance which stands much rough treatment. The molecules can exist in a state of independence as steam or water vapour: in a condition of semi-independence they associate themselves together as water. We know how much care has been given to the study of the water molecule in both these states. Now, in the second stage the molecules are arranged side by side and end to end to form the crystal of ice. It has been necessary to take away much of their motion in order to induce them to take the new form. They are no longer running hither and thither, twisting and spinning with the energy of their motion. They lie more quietly now, still quivering, no doubt, but tied together so that they can no longer change appreciably their relative positions. They are now the crystal to be investigated by the new methods: the result is shown in Fig. 3, already described.

We find that when the molecules are packed into the crystal pattern—and they do not seem to suffer much in the process—they are put together just as anyone would try to pack a box with objects all alike in shape but individually of irregular or, one might say, of awkward form. How would you pack a box full of boots? You would naturally put them in pairs, the right boot over the left in the familiar way. It is just such methods of packing that are followed in a crystal. It is convenient to illustrate by means of models. Here are a number of wooden "shoes" which are to represent molecules without symmetry in their form. Take four of them and put them together in the manner illustrated (Fig. 5). The result is a pattern which possesses a certain amount of symmetry,

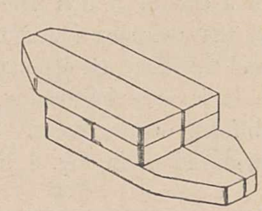


FIG. 5.—Arrangement of the four "shoes" showing the mutual orientation but not the mutual positions of the four molecules usually found in a monoclinic prismatic crystal such as benzoic acid or phthalic acid.

the same, in fact, as that of the boxes in Fig. 6. This is a very convenient form for packing, and it appears that a majority of known crystals pack together in this way. All of them show the symmetry that might

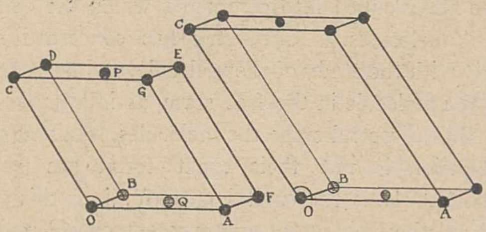


FIG. 6.—Unit cells of naphthalene and anthracene drawn to the same scale (10^8 to 1). It is apparently usual for cells of this kind to contain four molecules, but in these two cases they contain two only; that is because the molecules have some symmetry of their own. The molecules shown in Fig. 4 fit into the naphthalene cell. If the unshaded molecules be supposed to be placed with one end at Q, its general lie is parallel to OC. The two shaded molecules of Fig. 4 would then be placed with their ends at B and F. The anthracene molecule is like that of naphthalene except that there are three rings in a line instead of two; the axis OC is correspondingly larger.

be expected. They are exactly alike on either side of a dividing plane: in other words, they are exactly like their reflection in a mirror. They have, too, an "axis of symmetry"; a half turn about the axis brings no apparent change. Fig. 7 is an illustration

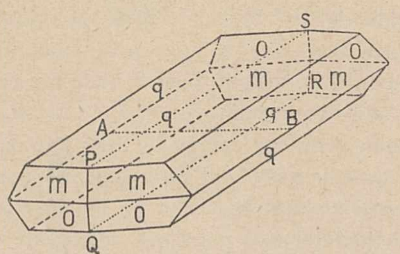


FIG. 7.—Phthalic acid, a monoclinic prismatic crystal possessing a plane of symmetry PQRS, and an axis of digonal symmetry AB, but there is no plane of symmetry through AB. Faces marked by the same letter are alike. The mutual orientation of the four molecules in its unit cell is that of the shoes in Fig. 5.

of a crystal of this kind. The X-ray methods show us that there are four molecules in the unit of pattern, and that they are arranged in the manner described.

It is very interesting to observe the result of a different arrangement. Sometimes a set of four are arranged as in Fig. 8, like two pairs of shoes back

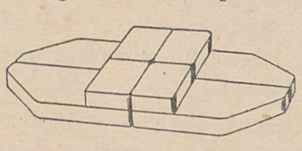


FIG. 8.—The relative orientations but not the relative positions of the four molecules in the crystal unit cell in resorcinol.

to back. The top and bottom are now unlike, but there is a greater symmetry in other directions. We have recently examined a crystal substance, resorcinol, which is built on this pattern; its external form is shown in Fig. 9. The fundamental molecule is a benzene ring in which two hydrogens have been replaced by two hydroxyl (oxygen-hydrogen) groups. The crystal shows clearly different forms at its two ends, the difference of which is shown in another very interesting way. If the crystal is warmed, one end of it becomes positively electrified and the other negatively. We have been able to go some way to the actual determination of the relative positions of the molecules: the results are shown in Fig. 10. There are two sets of planes perpendicular to the axis, which in the crystal occur alternately. In each plane there are two types of molecule, counting difference of orientation as difference of type. The plain lines in the diagram show the arrangement of the two types lying in the plane of the paper, and are marked A and D. One of them can be obtained from the other by a revolution through 180° in the plane. They are joined by long and by short lines, the former containing the oxygens of the hydroxyl groups. The arrangement of the next plane, above or below the first, is shown by the dotted lines: the molecules in this plane can be obtained from those in the first by reflections, with proper translations, across planes that are perpendicu-

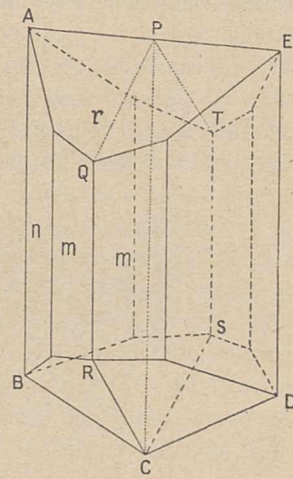


FIG. 9.—Resorcinol, a rhombic pyramidal crystal, having two planes of symmetry, AEDCB and PQRCST, and an axis of digonal symmetry PC.

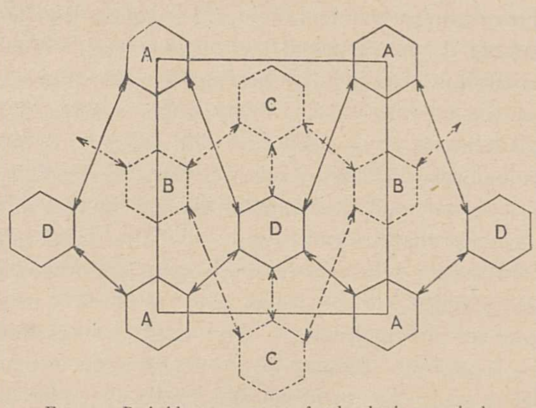


FIG. 10.—Probable arrangement of molecules in resorcinol.

lar to the paper and cut it in lines parallel to either of the sides of the rectangle. The arrangement is clearly governed by the necessity of fitting the molecules together so as to accommodate the hydroxyl attachment.

Another case of great interest and importance is the two-molecule cell, the two being exactly alike. How would you pack a box with boots all right-footed or all left-footed? You cannot find a way of packing which will make the result symmetrical on either side of a plane. Neither do you find a crystal, built on such a basis, to have right and left symmetry. The crystal of tartaric acid, investigation of the properties of which established the fame of Pasteur, is an excellent

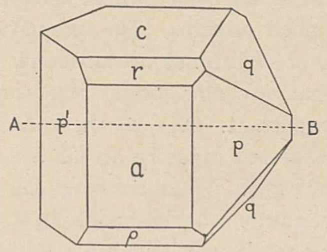


FIG. 11.—Tartaric acid, a monoclinic sphenoidal crystal, having an axis of digonal symmetry, AB, and no other axis or plane of symmetry.

example. Its peculiar form is shown in Fig. 11. A recent publication by Mr. Astbury gives the proof that there are two molecules in the unit cell. Their mode of arrangement in terms of "shoes," which are of one kind only, is shown in Fig. 12. The arrange-

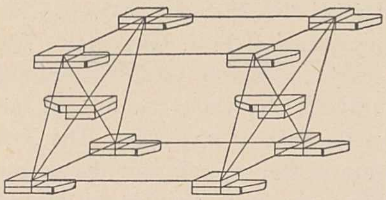


FIG. 12.—Arrangement of "shoes" of one kind only representing the arrangement of molecules in tartaric acid.

ment of the atoms in one molecule, represented in Fig. 12 by one shoe, is shown in Fig. 13. A model of the crystal is shown in Fig. 14; and diagrammatic representations of the atoms in two adjacent molecules are given in Fig. 15 (*a*) and (*b*): one of these figures is right-handed and the other left. The most striking

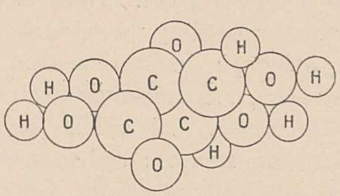


FIG. 13.—Molecule of tartaric acid.

physical property of the crystal is its power of rotating the plane of polarisation of light which traverses it. It has long been guessed that there must be some spiral arrangement in the structure: and this is beautifully confirmed in the model. There are, in fact, two spirals. This is somewhat unexpected, but it explains in a delightful way a property which has been obscure. One of the spirals is in the interior of the molecule itself and is certainly permanent when the crystal is dissolved. That accounts for the fact that tartaric acid in solution is "active," that is to say, can exercise its rotatory power. But the second spiral is a twist brought in by the necessity of fitting

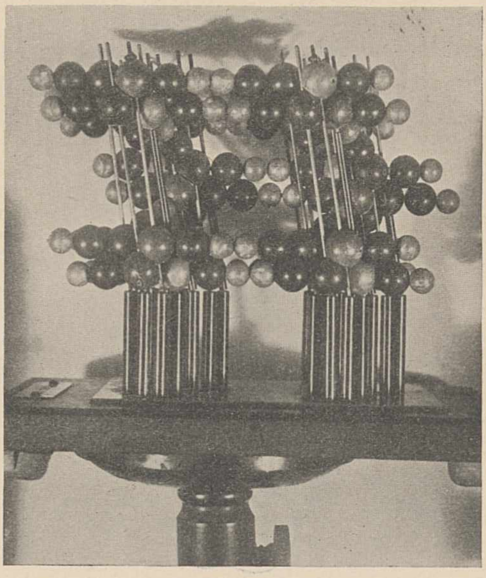


FIG. 14.—Tartaric acid. The small balls represent hydrogen atoms, the larger black balls oxygen, and the largest two grey and two black balls carbon. Scale of the model is 10^8 to 1.

the molecules in their places. It is a peculiarity of the crystal structure, not of the molecule: it is a right-handed screw if the first is a left-handed screw, and *vice versa*. Also it appears to be more powerful in its effect on the light; so that when the tartaric acid

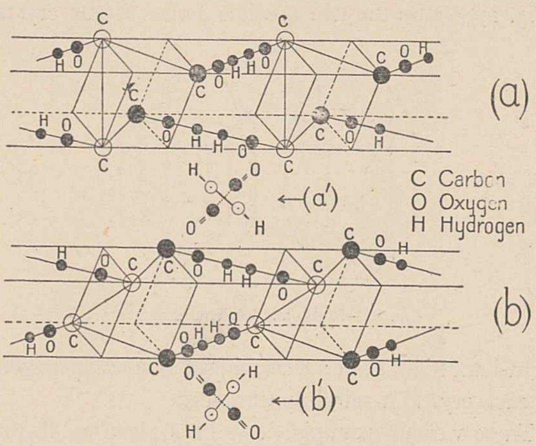


FIG. 15.—Tartaric acid; (a) and (b) represent two molecules end to end; (a') and (b') show corresponding cross-sections with the side attachment. The two sets of figures are right and left to each other.

as a crystal rotates light in one sense, in solution it rotates light in the opposite sense. Here, again, the intricate effects of the whole crystal are directly referred to structural details.

It is to be observed that in this case there could be no question of the existence in the crystal of two molecules related to one another as right to left. For the mirror reflection of a right-handed screw is a left-handed screw, and the whole effect depends on a want of balance. In this case also there is a plane of cleavage, passing through the points where the molecules join each other end to end.

Quartz is another example of a crystal possessing rotatory power, and like tartaric acid it contains a special element in its construction. The X-ray

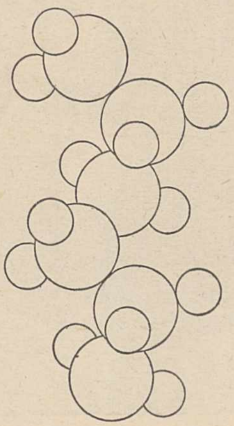


FIG. 16.—Spiral construction in quartz: large balls silicon, small balls oxygen.

methods make this very clear, and give us also some indications as to the structural system. In the model shown in Fig. 16 the large balls represent the atoms of silicon and the smaller those of oxygen. The spiral character of the fundamental crystal is beautifully manifested in its outward form. The illustration (Fig. 17) shows the two possible forms of the crystal,

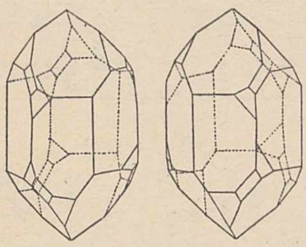


FIG. 17.—Right- and left-handed quartz.

right-handed and left; a certain set of small faces gives to each crystal a spiral appearance.

These various examples have been given as illustrations of the tasks which the new method of crystal analysis undertakes. They belong to a new field of research, akin to chemistry in that they seek to refer the properties of substances to the nature of the elements of construction. Chemistry has, however, concerned itself in the main with the relatively free molecules of liquids and gases: here we deal with the properties of the solid. Our concern is to explain the strength and elasticities of materials, their power of conducting electricity and heat, their electrical properties, optical properties: all these characteristics and many more, in terms of the structure as revealed by the X-ray analysis. Here are, we may say, the contributions of the method to pure science.

It is natural to say something of the possible application to applied science. The properties of solid materials are of such fundamental interest to all arts and crafts that any new insight into their origin is necessarily important. But, at the same time, applications of science to industry are always unexpected in nature and time. What we have now to do from the purely scientific side lies plain before us: how and when any result will have practical value cannot be foreseen.

Much attention has been given to the immensely interesting problems of the crystallisation of iron and steel. Westgren in Sweden, Bain in America, and others, have done good work on the structure of the various forms of iron, α, β, γ, and δ.

In Great Britain, the effect of the crystalline form on the strength of a material has been examined by G. I. Taylor and Miss Elam in the case of the beautiful aluminium crystals of Prof. Carpenter. The crystals are very easy to deform because certain planes of easy slip traverse the whole crystal, and these planes are always the first to give way. The X-rays show the structure of the crystals and the position of the planes. When the large crystals are broken up into smaller, oriented in all ways, the material becomes stronger because in whatever way a stress is brought to bear some of the crystals are ready to bear it.

Kaolinite, which can be examined, though in the form of a very fine powder, shows clearly a crystalline structure: by the same methods it can be shown that the structure disappears when the temperature is raised to a certain point. These facts were, at least in part, anticipated by the scientific branches of the pottery industry: but this method provides a useful confirmation, and further investigation promises to be very interesting. Calcined at 900° C., a new crystalline structure appears: and when the temperature has been sufficiently raised, the X-rays show that sillimannite has formed.

Such examples are mere pointers in a direction in which we may hope there will be a great movement in time to come. Our first aim is to develop the new methods as pure science. A broad, straight road opens out before us, and the going is good. As we travel along it we shall, doubtless, find many side turnings leading to useful applications, but we must not expect them until we are right opposite to them. Our first and obvious duty is to travel down the high-road as far as it will take us.