NATURE

SATURDAY, APRIL 26, 1924.

CONTENTS.

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

Advertisements and business letters should be addressed to the Publishers.
Editorial communications to the Editor.

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

The Protection of Scientific Discovery.

In Great Britain, and indeed in virtually the whole of the civilised world, ideas concerning the nature of property have been extended to include possessions far beyond those of a material character. Legislatures have elevated to the rank of property various intellectual products, and have endowed them with the proprietorial status which is associated more naturally with the holding of tangible estate. Rights have been conferred upon the authors of literary and artistic productions, while protection has been cast around designs, industrial models, and inventions. Although extensive, the area covered is not, however, coterminous with wide regions of mental activity, regions which still await full legal recognition. Between the copyright secured by authors and artists and the protection conferred upon inventors by patent, there are results of mental effort which, so soon as published, are open to exploitation by all and sundry with or without leave or licence. Scientific discovery which does not immediately manifest itself in patentable invention, or in a form which satisfies the requirements of copyright, has not yet secured for itself the attributes of legal property and its associated rights of ownership. This denial of right has received at length the attention of the League of Nations, it having been considered that one of the duties of a great organisation established for securing universal justice is to study the problem which an anomaly such as this presents and to propose means for terminating so unsatisfactory a condition of affairs.

In August last (NATURE, August 18, 1923, p. 246), we directed attention to a notice in the *Times* that the Intellectual Co-operation Committee of the League of Nations had decided to submit to the Council and to the Assembly a draft convention for the protection of scientific discoveries. We have now received an English translation of a Report which was submitted by Senator F. Ruffini and approved by the Committee.[1] The Report contains a powerful indictment of the injustice of the prevailing conditions as regards men of science, and suggests means for mitigating or removing the disabilities under which the scientific discoverer labours. "It is time to break," says the Report, "with the scandalous habit of considering scientific property as a public well from which everybody may draw at his discretion without owing anything to any one."

The Report is in two parts, the first containing a critical survey of the whole field under investigation, the second part being concerned with practical

[1] League of Nations. Committee on Intellectual Co-operation. Report on Scientific Property submitted by Senator F. Ruffini and approved by the Committee. A. 38, 1923, xii. Fcap. Pp. 28 and Table of Contents (Geneva).

proposals. The survey reviews in detail the problem which was before the Committee, and subjects to penetrating analysis jurisprudential ideas concerning intellectual property. It descants upon the rights of an author in relation to those of the inventor, and treats of general and specific objections which have been raised to the recognition of the rights of a scientific worker, and to the differences between artistic creation and scientific conception and their resulting legal consequences.

The second part of the Report, referring to the occasions from the year 1897 when the subject of the protection of discoveries has been raised, proceeds to discuss the desired amendment of the law, and whether the amendment should proceed by nations acting independently of one another, or whether as a preliminary measure an international convention directed to the same end should be secured. The practical means which might be taken for rewarding the scientific discoverer are dealt with at length, as is also the question whether the practice of conferring patent rights should be followed, or whether the precedent which results in copyright is preferable. The difficulties to be overcome are likewise indicated, and guiding principles are laid down for bettering the lot of the man of science as regards his unpatentable discoveries. The Report concludes with a draft international agreement and an independent memorandum.

Taken as a whole, the Report proves conclusively that justice, expediency, fairness, and logic are wholly in favour of protection being granted for scientific discoveries, but the Report speaks less convincingly upon the practical measures to be taken and upon the means for ensuring an equitable distribution of reward. Granting in the abstract that protection is desirable—against which so little is to be urged—the real difficulty occurs in respect to the means for securing the end in view, for, after all, it is upon the means that attention must finally be concentrated.

An impression derived from a study of the Report is the absence of the British view both as regards the jurisprudence and the means to be devised for furthering the aims of the Committee of the League. Continental ideas, however, with their customary confusion between legal and ethical rights, receive full attention. We are told, for example, that:

> "The right [of men of science] exists without the need of any formality to call it into being. This rule is merely the application of the common right of intellectual workers. The author of a work of art, of literature, of music, is the proprietor of his work by the sole fact that it is the child of his brain. No formality, no deposit, no declaration is required of him."

Amid the many authorities quoted there occur but two British writers; and of one of these it may be said without disrespect that the doctrine quoted from him is far from representative. The Report fails to notice, or notices insufficiently, that the protection which the inventor receives to-day in Great Britain is the outcome of history. With us, patent law was founded upon the desire to foster home industry, and so long as this aim was accomplished, the law was not scrupulously particular how it came about. During the Tudor and Stuart dynasties, when monopolies were given to impoverished courtiers and enterprising adventurers, it was but natural that the Crown fell back upon the granting of patents when help was solicited for introducing new industries. Patents had been, and were to continue, valuable sources of revenue. But the potentiality of the development of this exercise of the Crown's prerogative was extinguished by the Statute of Monopolies, which henceforth forbade the granting of monopolies except in favour of "any manner of new manufacture." Since that period, 1624, protection, step by step, has been conferred upon literary and artistic productions, to mention some instances; but public opinion has not even yet secured corresponding privileges in respect of useful arts which are not manufactures, and in respect of profound scientific truths, though such may be of world-wide importance. There springs to mind those biological discoveries by means of which vast fever-ridden areas in many parts of the globe have been cleansed of disease, and of which the accomplishment of the Panama Canal is an outstanding monument.

To-day, however, fair treatment between man and man calls for ameliorative measures. Justice demands that the scientific worker shall be placed in a position in which, if he chooses, he may secure reward in proportion to the importance of his discovery; expediency dictates that men of science should be encouraged by the hope of adequate recompense for their labour.

Now and again in Great Britain, endeavours have been made to influence public opinion, and practical schemes have been propounded, in this way following up the resolution of the International Congress of Inventors' Associations at Paris in 1900, that men of science should be protected by formal and effective legal provisions against the piracy to which they are constantly exposed. In 1914 the suggestion was made that the statutory definition of "invention," as appearing in the Patents Act of 1907, should be extended so as to include "any new and useful art founded on discovery" (*Science Progress*, No. 31, January 1914, p. 551 *et seq.*). An extension of this character, while proceeding far in the direction of protecting useful discoveries which were not inventions in the present sense of the term, and consequently are open to piracy, would vary the law but slightly. Yet it would result in the granting of patents to the scientific discoverers of principles or things which did immediately carry with them their practical application, although an application not within the sphere of manufactures.

Thus at the present day, "judge-made" law, as regards inventions which produce new and uncontemplated results of a striking character, has shown itself in favour of widening considerably the scope of their protection. By concentrating upon the novelty and importance of the results obtained from an invention and proportionately relegating to the background the means or methods for carrying out the invention, the Courts have progressed far towards conferring protection in respect of discoveries in general. They have done much; but they cannot do everything. Their efforts must be supplemented by legislation. The Committee, stating that it would be a fatal mistake to think that the activities of the organisation of the League are entirely absorbed and exhausted by political questions, boldly pronounces in favour of international agreement prior to local legislation, and submits a draft convention based upon conventions already in force for the protection of authors' rights by copyright and the protection of inventors by patents.

Discussion of the draft convention must be postponed to our next issue, when we also propose to examine practical means whereby the scientific worker may receive reward proportionately to the extent of the employment of his discovery.

(*To be concluded.*)

The British Dyestuff Industry.

IN the same sense as the nineteenth century was the mechanical age and witnessed the enormous development in productive capacity and social possibilities due to the extended use of machinery, so the twentieth century almost certainly will be known as the chemical age, in which the chief stimulus to human progress was given by the greatly increased application of science, and chiefly chemistry, to industry and other aspects of human activity. Thus it will come about, inevitably, that those countries which develop chemical industry to the greatest extent will be the commercial leaders in the hierarchy of nations, provided that the other essential factors of success, character and a concurrent development of the arts, are also present.

It is for the above reasons, and because organic chemistry offers an illimitable field for the tillage of utilitarian crops and an inexhaustible mine of products valuable in minimising human labour or increasing health and enjoyment, that the future of the British dyestuff industry is of such vast national importance; and a recognition of this fact has led the Council of the Institute of Chemistry, speaking for the majority of British chemists, to issue a memorandum on the subject to members of parliament, the Board of Trade, and the public. In this timely document, the national necessity of developing and maintaining a successful British dye-making industry is strongly urged from the viewpoint that it is the only industry at present capable of utilising the services of large numbers of trained organic research chemists; an adequate number of such chemists being essential to our national welfare, in peace as in war.

At the general meeting of the British Dyestuffs Corporation on April 8, the chairman, Sir Wm. Alexander, was able to announce that the Corporation was steadily improving its position, both financially and in respect of its production; but his remarks on the question of the proposed agreement with the great German combine, the Interessen-Gemeinschaft, known as the I.G., were of a negative and nebulous character. He said that much of the recent criticism had been misinformed, but admitted that the terms originally agreed upon had been modified to meet certain criticisms, and said that the agreement would in no way jeopardise the Corporation's independence and national character. This point can be judged only when the terms of the agreement are disclosed; but in view of the original terms to which the directors of the British Dyestuffs Corporation were presumably willing to agree, the document when it appears will have to be scrutinised very carefully, as under those terms the Corporation would have become a sort of super-*Deutschland*, bringing large cargoes of German dyes and German chemists to Britain.

At the moment, the centre of the negotiations appears to be in Britain and to be concerned with the adequate safeguarding of the interests of the colour users and of the British dyemakers outside the government-aided Corporation. The magnitude of the operations of the latter are not generally realised. It is stated that their combined capital and output exceed those of the British Dyestuff Corporation. The Council of the Institute of Chemistry has rendered an important public service by emphasising again the national aspect of this most important matter. W. M. G.

Abnormal Metabolism.

Inborn Errors of Metabolism. By Sir Archibald E. Garrod. (Oxford Medical Publications.) Second edition. Pp. vi+216. (London: H. Frowde and Hodder and Stoughton, 1923.) 7*s*. 6*d*. net.

THE first edition of this most valuable monograph was published by Sir Archibald Garrod in 1909, and was based on the Croonian lectures delivered by him before the Royal College of Physicians of London during the previous year. The past fifteen years have marked so rapid an advance in our knowledge of the bio-chemical processes occurring in the living organism that the appearance of a second edition, appropriately dedicated to Prof. Gowland Hopkins, will be welcomed by a wide circle of scientific readers.

The discussion of the subject of albinism, which in the earlier edition demonstrated the paucity of our knowledge of this subject, is now more satisfactory, since it includes a summary of the important results of the experimental work of Bloch on melanin formation, which were published some seven or eight years ago. It is now fairly generally accepted that his work has proved that the absence of pigment from the skin and hair of albinos is attributable to the lack of a specific agent, probably an enzyme, which by means of oxidative changes forms melanins from certain precursors. Bloch believed the parent substance of the melanins to be 3 : 4-dioxyphenylalanine, a base closely related to adrenaline, which is known to occur naturally in some plants. As yet, 3 : 4-dioxyphenylalanine has not been detected in animal tissues, and there is no proof that it is the precursor of the melanins responsible for the pigmentation of skin and hair. Indeed, Kreibich has shown that dimethyl-phenylene-diamine, a substance standing in no direct relation to 3 : 4-dioxyphenylalanine, can also be converted into a black pigment by an agent present in the cells of the basal layer of the epidermis. Whilst Bloch's views have been subjected to some criticism, they can still be regarded as having provided a working hypothesis, and a useful indication of at least one line of future research. The discussions of alkaptonuria and of cystinuria show that little additional information of outstanding importance has been recorded since the first edition of the monograph appeared in 1909. Much the same may be said about the chapter on pentosuria, except that the recent work of Cammidge and Howard would seem to have established that *r*-arabinose is the sugar present in the majority of urines from cases showing this abnormality.

The new volume is larger than the first edition by containing chapters on two abnormal conditions which Sir Archibald Garrod regards as inborn errors of metabolism. The first is hæmatoporphyria congenita, a condition characterised by the presence of relatively large amounts of porphyrin in the urine. The excretion of urine containing this pigment has been noted in certain acute conditions, particularly after the administration of certain drugs such as sulphonal or trional. In addition, however, cases have been recorded in which hæmatoporphyrinuria persists over long periods without association with acute toxic symptoms. Such cases show a greatly increased sensitivity to light, so much so that the eruptions on the skin which are produced by exposure to bright illumination may lead to blindness and most painful disfigurement. Fortunately, the condition would appear to be one of the rarest of those abnormalities of metabolism which can be inborn, for only some twenty cases have been recorded. The available evidence suggests that the porphyrin is derived from hæmoglobin, and that it may be an intermediate product in the conversion of the blood pigment into bilirubin. The condition doubtless stands in direct relationship to the observations of Hausmann that the injection of small doses of hæmatoporphyrin into white mice may be followed by death on exposure of the animal to a bright light, whereas the mice remained well so long as they were maintained in the dark. The second abnormal condition described by the author is congenital steatorrhæa, cases of which from birth onwards pass large amounts of fats in the fæces. This abnormality appears to be definitely associated with a deficiency of some factor normally present in the pancreatic secretion.

As Sir Archibald Garrod points out, it is probable that many other conditions exist which might be regarded as inborn errors of metabolism. The difficulty of discovering them is obvious, since only those which are characterised by a more or less striking phenomenon, such as the darkening of urine in a case of alkaptonuria, are likely to be detected except by a most tedious routine examination. As the author has pointed out, one man in 20,000 who habitually excreted a gram or two of aspartic acid daily in the urine might well be overlooked. Nevertheless, since 1909, two more inborn errors have been added to the list, and we may hope that their close examination may lead to the acquisition of important knowledge concerning the metabolism of blood pigment and of fats, just as the study of cystinuria and alkaptonuria has yielded much valuable information regarding the intermediate stages of protein metabolism.

J. C. D.

The History of the Plant World.

Extinct Plants and Problems of Evolution: Founded on a Course of Public Lectures delivered at the University College of Wales, Aberystwyth, in 1922. By Dr. Dukinfield Henry Scott. Pp. xiv + 240. (London: Macmillan and Co., Ltd., 1924.) 10*s*. 6*d*. net.

IN this attractive and well-illustrated volume, based on lectures delivered to a general audience, the author reviews the geological history of plants in relation to evolutionary questions. The subject is treated in broad outline, and preference is given to such groups as are represented by the greatest number of types. The difficulty of deciding what to omit has been successfully met, and the author has avoided the common mistake of using technical terms without explanation. We have often been assured that the palæobotanical record affords clear evidence in support of the gradual unfolding of plant-life through the ages, and it is not difficult by carefully selecting a few examples from the imperfect documents available to us to produce a more or less convincing story. But a student who takes an impartial retrospect soon discovers that the fossil record raises more problems than it solves. The oldest inhabitants of the land of which we have any definite knowledge, though in some respects simpler than any existing vascular types, are surprisingly advanced; they tell us but little more than we can learn from living forms of the origin of morphological features characteristic of terrestrial plants.

In the introductory chapter, the author deals very successfully with some current problems of evolution: after recalling a reference to Darwinism by a Nonconformist divine as "the offspring of the sin-diseased brain," he gives a particularly clear account of the maze-like method of development of evolutionary thought. This chapter is one of the best in the book. After briefly describing the main divisions of the vegetable kingdom as we know it to-day, Dr. Scott works backwards from the present to the remote past: while recognising some slight advantage in this reversal of the usual practice of writing history, one misses the stimulus of contact with the unfamiliar and the expectation of what is to come experienced by a traveller who starts from the unknown hoping at successive stages of his journey to discover sign-posts pointing the way to the world which he knows.

The problem of the ancestry of the flowering plants is clearly stated: it is admitted that despite striking analogies between the present dominant Angiosperms and the once dominant Cycadeoids of the Mesozoic era, there still remains a wide gap. The existence of a real affinity has not been established. Dr. Scott has many qualifications which inspire confidence: he adopts a sound, judicial attitude in summing up evidence; he can change his mind, and does not hesitate to do so. The seed-bearing plants of the later Palæozoic periods are no longer regarded as generalised types indicating a common origin, from some unknown ancestor, of Ferns and Cycads, but are considered to be an independent group which, it is suggested, may have given rise to the Cycadophyta. As in other instances, we cannot tell whether certain resemblances denote affinity or are merely parallel developments: it is with difficulty that one breaks away from the habit of interpreting as connecting links structural resemblances which are probably of no phylogenetic significance.

The present tendency is to discard the old-fashioned genealogical tree with its wonderful diversity of branches and to think of the several groups as separate lines of development from independent, simple progenitors. As the author says, "we know a good deal about extinct plants, but not enough, as yet, to throw much light on the problems of their evolution." Dr. Scott, if one may venture to say so, has lost faith in the branching-tree method of expressing the course of evolution; but the influence of the old tradition, though weakened, is still operative. Evolution is an established fact; but of the manner of it we are profoundly ignorant. Dr. Scott has done good service by his candid statement of the difficulties presented by the study of the rocks and by encouraging students to look for solutions in one of the most fascinating fields of research. We want to know where we are: faith, as Dr. Bateson says, has given place to agnosticism: it is necessary to start afresh, to see things as they are and not as we think they should be.

In the last chapter, special attention is given to the now famous Devonian plants from the Rhynie chert; a sympathetic reference is made to Dr. Church's able exposition of the transmigration theory, and the suggestion made by the reviewer that Palæozoic and Mesozoic floras are not connected by satisfactory links is critically discussed. "The whole course of Nature is dominated by periodic events": it is popularly believed that there was one beginning and then a steady progress; but there is another view, expressed by Suess some years ago, which has not received the attention it deserves, that changes in the inorganic world played a compelling part in the evolution of the organic world. Revolutions in the earth's crust may have led not only to fresh beginnings, but also to relatively sudden and drastic changes in the process of evolution.

These admirably sane and lucid lectures in which palæobotanical data are considered, if they do not furnish answers to leading questions, at least give us the best that is available, and in a style which is singularly happy and stimulating. The suggestion may be offered that in a second edition, subject-headings to the pages should be substituted for the irritating repetition of the title of the book. A. C. SEWARD.

Universities of the Empire.

The Yearbook of the Universities of the Empire, 1924. Edited by W. H. Dawson, and published for the Universities Bureau of the British Empire. Pp. xii+756. (London: G. Bell and Sons, Ltd., 1924.) 7*s.* 6*d.* net.

"THE Yearbook of the Universities of the Empire," published for the Universities Bureau of the British Empire, has now become a work of reference which is indispensable to all those concerned in higher education and research. It is more than that, however: it is a document of great significance to students of the great educational and social movements of the times.

Of its value as a work of reference it is indeed almost superfluous to speak. Since its publication in 1914 it has been steadily added to and improved. Experience has indicated what rearrangements are necessary, and by the assistance of some ingenious typographical devices a mass of accurate information has been compressed into its 700 pages. The result is a well-balanced survey of the activities of all the universities in the Empire; it gives also (in a series of appendices) a guide to the entrance to the professions, particulars of scholarships and grants for research, notes on foreign universities, valuable statements regarding the distribution of groups of subjects in the universities and university colleges of the British Isles, and details of those subjects to which particular attention is given by the various institutions.

Two of the appendices are of especial interest, namely, those relating to students from overseas at universities in the British Isles, and to the comparative numbers of students following university courses. There are now more than 4000 overseas students distributed among the English and Scottish universities, of whom a quarter are from India and more than 700 from South Africa. The other Dominions are not so strongly represented; Australia, Canada, and New Zealand sending only 176, 165, and 103 respectively. London naturally receives the largest proportion, except in the case of the 402 students from the United States of America, of whom 213, including presumably the Rhodes scholars, are at Oxford. It is known that a great proportion of these overseas students are post-graduate students, and the movement set on foot during the War for encouraging such students to take advantage of the facilities, in some respects unrivalled, offered by Great Britain, is certainly bearing fruit.

The comparative statistics of university students for 1912–13 and 1922–23 prompt some interesting speculations. There is a great all-round increase in numbers, and, in the newer universities, a doubling. The increase in the number of overseas students to which reference has been made does not account for the difference, nor are there any considerable numbers of ex-service men now in attendance. Not only have the universities "survived" the War, but they have, in spite of the industrial depression, emerged from it strengthened in numbers and carrying heavier and greater responsibilities. It seems to be a legitimate inference that we are developing a "university habit," and that the necessity of a university training is being recognised by a wider section of the community. This is, on national grounds, all to the good, though we have a lot of leeway yet to make up before our proportion of university-trained population approaches that of France or the United States. Will Parliament show its appreciation of the work the universities are discharging? The total grant at present spent on universities is less—very considerably less—than the cost of one battle-cruiser.

Projective and Analytical Geometry.

(1) *An Introduction to Projective Geometry.* By Prof. R. M. Winger. Pp. xiii+443. (Boston, New York and Chicago: D. C. Heath and Co.; London: G. G. Harrap and Co., Ltd., 1923.) 12*s*. 6*d*. net.

(2) *Analytic Geometry.* By Prof. C. E. Love. Pp. xiv+306. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1923.) 10*s*. 6*d*. net.

(3) *Plane and Solid Analytic Geometry.* By Prof. W. F. Osgood and Prof. W. C. Graustein. Pp. xvii+614. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1922.) 14*s*. net.

(4) *Lehrbuch der analytischen Geometrie.* Von Prof. Lothar Heffter. Band 2: *Geometrie im Bündel und im Raum.* Pp. xii+421. (Leipzig und Berlin: B. G. Teubner, 1923.) 9*s*. 5*d*.

(1) PROF. WINGER'S work is intended by the author to serve as an introduction to the higher parts of modern geometry, and on the whole well serves this purpose. It covers much ground, and is clear and concise, though on the other hand it is impossible not to remark on the minor inaccuracies with which the book is strewn. For example, on page 54 it is assumed that the value of a divergent series is infinite; or again, the term "degree" is used in several places where "order" is plainly implied (to refer to the degree of a space curve is meaningless). The author has not realised the necessity of restricting most statements to the general case.

The book starts with certain fundamental ideas to the early introduction of which too great praise cannot be given, but a knowledge of elementary geometry and nomenclature is assumed which is scarcely justified; for example, the order and class of curves are introduced without definition. In fact, in our opinion the first chapter could have been devoted to a sketch (at least) of the logical foundations of the theory, and this would then have led naturally to the chapter on non-Euclidean geometry with which the book closes, which at present is rather detached from the rest of the discussion.

The first six chapters are devoted to developing the projective theory in the customary metrical manner.

Chaps. viii. and ix. contain a good account of the theory of binary forms in their geometric aspect, and afterwards the study of the conic is resumed. It is considered first in connexion with the parametric representation (together with the theory of plane rational curves in general), and afterwards as represented by a ternary equation. The former is perhaps the first adequate elementary account of this aspect of the analytical theory of the conic, in English at any rate. We cannot, however, agree with the statement that the line conic associated with a point conic, degenerating into a repeated line, is arbitrary. The line conic consists precisely of a pair of pencils the centres of which lie on the line. It is true, indeed, that these are indeterminate if the line alone is given; but if the conic arises as a degenerate case in a definite geometrical problem, then the line conic is perfectly definite, in general.

Chap. xi. deals with plane collineations, and the following chapter with some higher applications of the invariant theory. It would have been fairer to the reader to have pointed out that the term "involution" is employed in a more general sense than that which is customary. The preference over "linear series" is not explained, and the important special case of a linear series ∞^1 is left without a special term. The remark on p. 356 justifying the application of the term to an ∞^1 as well as to an ∞^2 must be due to a confusion, for it would also justify calling a line a plane. In the chapter the linear series of ∞^2 sets of three points is considered, and is applied to an interesting, if somewhat artificial, account of rational plane cubics.

(2) Prof. Love's work is an unambitious but rather successful book dealing with elementary algebraic geometry so far as the principal properties of conics, and in three dimensions the geometry of the line and plane, and the classification and topology of quadrics. It will be useful for many purposes to have a book which includes in one cover the geometry required for the lower public and university examinations, and this book will, we think, be found suitable for the purpose.

(3) A book covering much the same ground as the last but for an ill-arranged account of the main properties of quadrics. It has apparently been written to suit a particular set of courses, and no doubt will serve that purpose, though it can scarcely expect wider recognition. The book is verbose, and the standard variable, due probably to a wish to mention everything, even when an adequate account was out of the question. We cannot help thinking that the introduction of mechanical proofs (so-called) will be found very irritating, illogical, and calculated to give beginners a totally false impression of the relations of pure and applied mathematics. The same applies in only a slightly less degree to notations and illustrations derived from applied mathematics.

(4) This treatise is of rather a different type from the others, and, like Prof. Heffter's former volume, is constructed on lines unfamiliar to English readers. Without going very far it covers the ground with extreme thoroughness, dealing first with the star and later with space, in the logical order, starting with the projective space (in the latter case), and passing via the affine space to the equiform space. We regret, however, the absence of the invariant theory for quadrics, and the closing chapter on cubic and quartic curves in space does not do justice to these important curves, and is scarcely up to the standard of the rest of the book.

C. G. F. J.

Our Bookshelf.

The Chemistry and Physics of Clays and other Ceramic Materials. By Alfred B. Searle. Pp. xiii + 695. (London: Ernest Benn, Ltd., 1924.) 55*s*. net.

This is a monumental book of nearly 700 pages, written by an expert adviser in the ceramic industry. The author points out the initial difficulties attendant upon the application of science to an ancient industry that has reached a remarkable level of craftsmanship. It is clear that science has caught up with empirical knowledge in a number of important directions, and is already pointing the way to great technical advances. In spite of this the scientific worker has not yet accumulated sufficient material, nor is the industry ready, for a volume dealing mainly with the theoretical study of the problems. The author has therefore compiled the present volume with one eye on the student and the other on the manufacturer, and he has maintained throughout an almost entire absence of strabismus. This is no mean achievement.

One outstanding point that emerges from a study of this book is the very close relationships between ceramic and agricultural investigations on the properties of clay. The former are by no means confined to the behaviour of the material during or after firing, although this process naturally received at first the bulk of the attention. But the properties of the moist and plastic mass, and the changes in the physical state effected by water, are at least as important, and here the ceramist is attacking, from the opposite end, precisely the same problem as the agriculturist. Although it would be dangerous to press the statement too far, in a general way it is perfectly true that both groups of workers are vitally concerned with the tilth of the material; but whereas the ceramist needs a bad tilth, the agriculturist endeavours to produce a good one. One turns with interest, therefore, to chapters vii. and viii., dealing with the changes in the physical state of clay effected by addition and removal of water, to see how far the author has drawn on the considerable body of information available in modern agricultural science. Most of the essential features are included, although the treatment is not exhaustive. In particular the discussion of shrinkage, in chapter viii., is scanty and rather obscure. It could usefully be expanded in the light of Haines's recent paper in the *Journal of Agricultural Science*.

There can be no question as to the value of the book to all interested in ceramics, and it will be useful also to research workers engaged in the study of soil.

B. A. K.

Mechanics via the Calculus. By P. W. Norris and W. Seymour Legge. Pp. xi + 340. (London: Longmans, Green and Co., 1923.) 12*s.* 6*d.* net.

THERE really is room for a good text-book on applied mathematics for engineering and physics students at the universities, as well as for such students of mathematics as are content with a pass course in the subject. The ground covered should be that covered by Messrs. Norris and Legge, and the scope should be that of their "Mechanics via the Calculus." Yet in spite of these coincidences one cannot say that the present book supplies the want. The authors have evidently taken great pains to collect all the pieces of knowledge that the student should acquire; they do large numbers of examples and set still greater numbers for the student to solve. But there is one fatal defect—there is no thread in the treatment of the subject, no soul in its development. The book is a compilation, "useful but unenlightened," of all the standard bits of book-work, strung together often without rhyme or reason. A book on mechanics without some kind of inspiration is another torture for the teacher and the pupil.

The book is not attractive in any other sense, even as regards paper and type, but our chief objections are to the actual treatment and to some misleading features. "A central force is a force whose intensity is some function of the distance from a fixed point," say the authors. There is often a total disregard of conventional notation: what is the poor student to do when he reads other works? Pages 1-3 are sufficient to cool the ardour of all aspirants after mechanics via the calculus. In dealing with simple harmonic motion, the velocity is asserted to be positive in the solution, and is then allowed to have all signs in the result! The argument in Ex. x., p. 176, is at least dangerous, and the result inconclusive. These and other faults in this book lead us to conclude that such an excellent book as Lamb's "Dynamics" must continue to be used by even pass students, until a really satisfactory book is produced for their benefit.

S. BRODETSKY.

Luxor and its Temples. By Dr. A. M. Blackman. Pp. xii + 200 + 24 plates. (London: A. and C. Black, Ltd., 1923.) 7*s.* 6*d.* net.

NOTWITHSTANDING its title, Dr. Blackman's book is not a description of Luxor in the guide-book sense. It is a popular account of life as lived by the inhabitants of ancient Thebes. Dr. Blackman has opportunely provided exactly the type of book required by the ordinary reader, whose knowledge of Egyptian culture and history is vague, to appreciate the significance of the objects from the Royal Tomb in the Valley of the Kings which have been described in the daily press, as well as to form some idea of the religious and social environment of which they were the product. Dr. Blackman has aimed at showing that the ancient Egyptians were by no means a gloomy people, and that our knowledge of their culture is not confined to mummy-cases and funerary apparatus. The admonitions of the sage Ani to his scapegrace son, and the poetry the author quotes, reveal a joyous spirit which belongs to all time.

In view of the special character of the public for whom the book is intended, the historical notes on the great rulers of the Empire might have been more extended and systematic; but the summary of events before the XIIth Dynasty is exactly what is required. The same remark applies to the references, brief as they are, to the variation in the importance of the chief cities of Egypt from time to time. It would have been a distinct gain had the author dealt more comprehensively with the Egyptian deities. Possibly he regarded this, as well as the Aton worship, as outside his scope, or, may we venture to hope, has reserved these subjects, upon which he is well qualified to write, for a future volume. The sketches by Major Fletcher are delightful, and add considerably to the charm of a most attractive book.

Elements of Optical Mineralogy: an Introduction to Microscopic Petrography. By N. H. Winchell and A. N. Winchell. Entirely rewritten and much enlarged by Prof. Alexander N. Winchell. Second edition. Part 1: *Principles and Methods.* Pp. xv + 216. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1922.) 17*s.* 6*d.* net.

THIS work differs from the older standard text-books on the subject mainly in respect of mode of treatment, which is somewhat more detailed, and in its inclusion of tutorial sections devoted to practical laboratory work, carefully graded. Graphical construction largely replaces mathematical discussion. There are 251 excellent illustrations, many of which are new.

The text and tutorial sections dealing with biaxial minerals are specially praiseworthy: extreme care, and an intimate acquaintance with the student's difficulties, direct the authors' treatment of interference figures, dispersion, the determination of "sign," and the behaviour of the isogyre.

The conception of wave-fronts, wave-velocities, etc., has been developed rather too much at the expense of the index-ellipsoid or indicatrix. As a consequence, helpful corollaries to the proposition that a mineral slice corresponds, approximately, to some particular indicatrix-section escape precise enunciation—from p. 106 onwards. As the student may ultimately wish to consult standard text-books (in English) on descriptive mineralogy, the authors' use of Np, Nm, Ng in preference to α, β, γ seems undesirable. Text references to Figs. 90, 108, 115, and 120 require slight revision.

The work as a whole is a painstaking and successful effort to reduce the difficulty which the subject usually presents to the beginner.

A. B.

X-rays: their Origin, Dosage, and Practical Application. By W. E. Schall. Pp. vi + 119. (Bristol: J. Wright and Sons, Ltd., 1923.) 5*s.*

THE author's aim has been to explain the various means by which X-rays can be produced, their main physical characteristics, and the conditions under which the rays can be most efficiently, safely, and accurately used in medical work. In this he has succeeded to a very considerable extent in a book of comparatively small size; perhaps the scope is a little wider than the size of the book warrants, but this is not a serious fault.

The first four chapters are devoted to the means of production of X-rays, their properties and measurement, and here the author writes with evident experience of many of the difficulties of the subject. Then follow two chapters upon diagnostic and therapeutic applications. In the medical uses of X-rays to-day, there is a much greater disposition on the part of radiologists to approach the subject from a quantitative point of view, and in no part of X-ray work is this more evident than in the efforts which are made to get an accurate idea of the dose of radiation administered to a patient. Owing to the scattering of the primary beam as it penetrates the tissues, this is a very difficult quantity to estimate. However, much has been done, notably by Friedrich and Dessauer, who have given data appropriate to certain experimental conditions frequently realised in medical practice. These data and others applicable to associated problems are collected in tables which form the last 15 pages of the book.

The book is well illustrated with line-drawings and photographs, and should be of considerable service to radiologists.

An Elementary Text-Book of Australian Forest Botany. By C. T. White. (Published under the direction of the Forestry Commissioners of New South Wales.) Vol. 1. Pp. v+223. (Sydney: John Spence, 1922.) n.p.

The work under notice is the first volume of a useful text-book on the botany of Australian trees. Seven chapters are devoted to morphology, and deal with root, stem, leaf, flower, inflorescence, fruit and seed, and accessory organs. The technical terms are illustrated by examples taken from native trees and shrubs; and much information of a novel character is incidentally given. Thus attention is directed to the peculiar aerial roots of Melaleuca, the varied barks and two kinds of seeds of the Eucalypti, and the leafy organs of Acacia and Phyllocladus. The remarkable stages in the growth of leopard wood, *Flindersia maculosa*, are well shown in three photographs. This plant begins life as a thorny, almost leafless, wide-spreading shrub, and ends as a smooth, graceful tree with unarmed leafy branches.

Three chapters, assigned to anatomy, treat of the microscopic structure and the development of the cells, tissues, and organs of arborescent plants; and special attention is paid to the structure of the stem, annual rings, medullary rays, heartwood, knots, bark formation, and healing of wounds. The physiological part, comprising five chapters, is an elementary account of the nutritive and reproductive functions of trees. There are 105 figures in the text, mostly diagrams of a helpful kind; and a full index is appended.

Givers of Life and their Significance in Mythology. By Prof. M. A. Canney. Pp. vii+114. (London: A. and C. Black, Ltd., 1923.) 3*s.* 6*d.* net.

Prof. Canney devotes the first four chapters of his little book to an exposition of the theory that certain conceptions of primitive religion are to be traced to a belief in the life-giving properties of certain substances, which, in turn, is derivative by association from the functions and qualities of the human body with which the "new psychology" has shown the primitive or subconscious mind to be largely preoccupied. Taking the three well-known and widely distributed beliefs in the magical efficacy of the word, the name, and the hand, Prof. Canney's object is to show that these beliefs are based upon the fact that the word, the name, and the hand are regarded as givers of life—in the case of the first two through their close association with such conceptions as the magical quality of the mouth, the breath, the spittle, and the like, while the last is closely connected with phallic symbolism. Prof. Canney's analysis of these beliefs is both lucid and suggestive, especially in connexion with the protective symbolism of the hand. It may, however, be pointed out that a change of name sometimes seems to link up with the idea of protection by disguise rather than that of new birth.

Jacksonian Essay. The Effects of Radium upon Living Tissues: with Special Reference to its Use in the Treatment of Malignant Disease. By Dr. Sidney Forsdike. Pp. 72 + 9 plates. (London: H. K. Lewis and Co., Ltd., 1923.) 5*s.* net.

Dr. Forsdike's Jacksonian Essay is an account of the effects of radium on normal and on pathological tissue. His own experiments were carried out on the ovaries of cats, and they show that the first and most important effect is on the nucleus of the primary follicles, and that capillary endothelium, ovarian follicles, lymphatic tissue, and leucocytes are more susceptible to radiation than are nervous, fibrous, and cartilaginous cells, especially in embryonic tissue. It is this selective action which makes possible the destruction by radium of malignant tissue cells.

The clinical results of such treatment are distinctly encouraging, and demonstrate clearly the possibility of radium therapy as a radical treatment of cancer. Dr. Forsdike also includes a paper on the treatment of severe and persistent uterine hæmorrhage by radium, and shows its advantages in many cases over X-ray and operative treatments. The book is well illustrated by photo-micrographs.

Analytical Microscopy: its Aims and Methods. By T. E. Wallis. Pp. viii+149. (London: E. Arnold and Co., 1923.) 6*s.* net.

The analyst and pharmacist are frequently confronted with problems to be solved satisfactorily only by the skilled use of microscopical methods, which are, however, strictly neither bacteriological nor physiological in nature. The author in this little book has brought together a selection of the principal methods employed in the microscopical examination of numerous miscellaneous substances, *e.g.* cattle and poultry foods, jams, lozenges, ointments, and various foods, beverages, and condiments. This information is, it is true, available, but is contained in many scattered and often expensive volumes, and the epitome here presented should be very useful. The text is illustrated with many figures, and in the last chapter a good account is given of certain quantitative methods, *e.g.* the enumeration of starch grains in a powder, by admixture with a weighed amount of lycopodium, the number of spores of which per milligram has been computed.

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.*]

Further Determinations of the Curvature Radius of Space-Time.

IN continuation of my letter of January 1 on this subject, published in NATURE of March 8, p. 350, I should like to add, in the first place, two more items to the list of eight R-values then determined from seven globular clusters and the Lesser Magellanic Cloud. According to R. E. Wilson (Publs. of the Lick Observatory, 13, part 5, 1918, p. 187) the Greater Magellanic Cloud shows a spectrum shift

$$cD = +276 \text{ km./sec.},$$

this being the mean of seventeen but slightly different effects for as many nebulæ distributed over the area of the cloud. The distance of this cloud is estimated by Shapley (*Astrophys. Journ.* 49, 1919, p. 322) at 61,000 light-years or

$$r = 3{\cdot}84 \,.\, 10^9 \text{ astronomical units.}$$

Thus, again by the approximate formula $D = \pm r/R$,

$$R = 4{\cdot}2 \,.\, 10^{12} \qquad \text{(Gr. Mag. Cl.)}$$

For the globular cluster N.G.C. 6218, or Messier 12, Sanford finds (Mt. Wilson Annual Report for 1919, p. 250)

$$cD = +160 \text{ km./sec.},$$

and, as I have just learned from Prof. Shapley, its distance is estimated by him at 12,400 parsecs, with probable error of about 2500 parsecs, whence

$$R = (4{\cdot}8 \pm 0{\cdot}9)10^{12} \qquad \text{(N.G.C. 6218)}$$

Both of these are in good harmony with the previous eight R-values. The last-mentioned cluster is also remarkable inasmuch as, being placed at materially the same distance as one of the previous clusters, it shows a Doppler effect of the opposite sign but of just the same absolute value, in accordance with the approximate formula. We have, in fact,

N.G.C. 6341, $r = 12{,}300$ parsecs ; $cD = -160$ km./sec.,
N.G.C. 6218, $r = 12{,}400$ parsecs ; $cD = +160$ km./sec.

No stress, of course, will be put on the exact coincidence of these two effects.

All the ten R-values, thus far obtained, namely from the eight globular clusters N.G.C. 5024, 5272, 6205, 6333, 6341, 6934, 7078, 6218, and the Lesser and the Greater Magellanic Clouds are, respectively,

6·7, 6·7, 2·2, 6·7, 4·7, 5·7, 9·1, 4·8, 4·0, 4·2 *million million astronomical units* . . . . (1)

If, as was previously assumed, β^2 or v_0^2/c^2 is really negligible for all these celestial objects in the presence of r^2/R^2, the differences between these ten R-values may be looked upon as due to observation errors affecting both the values of D and, perhaps more so, those of r. If so, then we may strike an average over these ten determinations, which would give

$$R = 5{\cdot}5 \,.\, 10^{12} \qquad . \quad . \quad . \quad (1a)$$

This might well be justified by the large, nay uncertain, P.E. of most of the observations used in the set (1).

If, on the other hand, we remount to the rigorous formula (3) of the first letter, which materially reduces to

$$D^2 = \frac{r^2}{R^2} + \frac{v_0^2}{c^2} = \sigma^2 + \beta^2, \quad . \quad . \quad . \quad (2)$$

and if each of the ten pairs of data is considered to be correct, we must conclude that even the largest R-value of the set (1) derived from them is the lower limit of (or possibly the true value of) the world radius, *i.e.*

$$R \geqq 9{\cdot}1 \,.\, 10^{12}, \quad . \quad . \quad . \quad (2a)$$

with a strong presumption, however, that R does not much exceed 10^{13} astronomical units. The fairest way of representing, at least for the present, the experimental findings, would seem that suggested to me by Russell in one of many helpful conversations during February at Toronto (where Prof. Russell gave us, also, a series of inspiring lectures on astrophysics), and that is, to plot the absolute values of D against the distances r, as in the accompanying graph (Fig. 1), where the finite length of the vertical

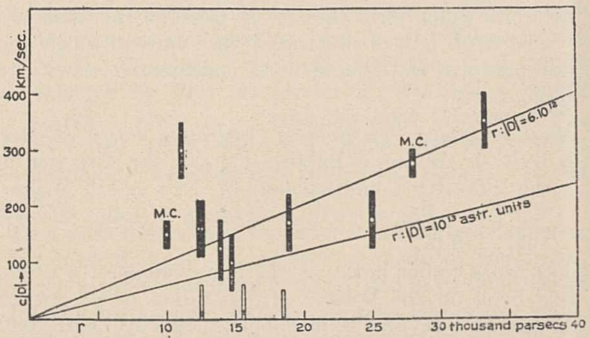

FIG. 1.

strokes corresponds to the P.E. of the Doppler effects, so far as they are estimated.

To the set of ten data (1) three more are added in the graph for the sake of impartial completeness. These three were previously discarded as giving suspiciously small effects of +10, zero, and −10 km./sec. ; they belong to the globular clusters N.G.C. 5904, 6626, 7089, placed by Shapley at 12, 18, and 16 thousand parsecs, respectively. If R is at all finite, the strokes, or rather their *upper* extremities, should not fall below a certain straight line, $|D| = r/R$, drawn through the origin. That there is, thus far, an indication of such a state of affairs, making a value of R of the order 10^{12} to 10^{13} very likely, can scarcely be doubted. But to strengthen this impression a large number of similar data would still be required.

Thus far the announced extension of the list given in the previous letter.

In the next place, attention may be directed to the more complete formula (2), which takes account of the integration constant v_0, an individual attribute of the history of a celestial object. Owing to the fortunate circumstance that our observing station is not the sun itself (our previous O), but is revolving around it periodically, this formula can be utilised to determine from a pair of spectrograms, taken over half a year or so apart, both the star constant v_0 and $\sigma = r/R$, and, if r be estimated, the required value of R. In fact, if V be the velocity of the observing station due to the earth's annual, and diurnal, motion projected upon the line of sight (from sun to star), as familiar to astronomers from "reduction to sun," we shall have, apart from niceties of a purely academic interest, instead of (2),

$$D^2 = \frac{r^2}{R^2} + \frac{1}{c^2}(V - v_0)^2,$$

v_0 being counted positive for receding motion, and r being the star's distance from the sun at the moment of observation. Now, let two spectrograms, preferably half a year apart, be taken of the same celestial object, giving the (unreduced) Doppler effects D_1, D_2. Then

$$\left.\begin{aligned} D_1^2 &= \frac{r^2}{R^2} + \frac{1}{c^2}(V_1 - v_0)^2 \\ D_2^2 &= \frac{r^2}{R^2} + \frac{1}{c^2}(V_2 - v_0)^2 \end{aligned}\right\} \quad . \quad . \quad . \quad (3)$$

will be two equations for the two unknowns v_0 and $\sigma = r/R$. Since even for the quickest celestial object ever observed the change of r within six months—nay, within many centuries—is much less than the P.E. of the distance estimate, we have confounded r_1 with r_2 writing r for either. Eliminating r/R we have

$$2v_0(V_2 - V_1) = c^2(D_1^2 - D_2^2) - (V_1^2 - V_2^2), \quad . \quad (4)$$

which determines v_0. This being substituted into the first or the second of (3) will give σ, the star's distance with R as unit. Even if no estimate of r is available, σ will be a welcome piece of information. Notice that if R were infinite, we should have

$$c(D_1 - D_2) = V_1 - V_2,$$

which affords the possibility of a preliminary test. If r is accessible to measurement, (3) will give v_0 as well as R. To give the first term a fair chance for co-operation, objects not less distant than 1000 parsecs or so should be chosen. At any rate, this method will be applicable to less distant and, therefore, to much more numerous celestial objects than that based upon the assumption of a negligible v_0, for which objects so distant as 10 to 40 thousand parsecs were chosen. The results of the application of formulæ (3) to some existing data and to other material which, at the writer's request, Mr. H. H. Plaskett, of the Dominion Observatory at Victoria, B.C., is now preparing to obtain from 10 Lacertæ and possibly some other stars, will be given in later communications.

LUDWIK SILBERSTEIN.

129 Seneca Parkway, Rochester, N.Y.,
March 3.

The Artificial Disintegration of Atoms.

IN a letter published in NATURE of September 15, 1923, we gave some results of our experiments on the artificial disintegration of atoms, which indicate that the atoms of beryllium, magnesium, and silicon are broken up by the impact of swift α-particles and give off H-nuclei of different ranges, exceeding 7 cm. in air.

According to a recent communication by Sir Ernest Rutherford and Dr. J. Chadwick (NATURE, March 29, p. 457), these authors, working by different methods, have confirmed our results with regard to magnesium and silicon, whereas with beryllium the evidence so far obtained is apparently less decisive. A number of other elements, including oxygen and carbon, were tested with negative results, whereas with neon, sulphur, chlorine, potassium, and argon, H-particles of a range exceeding 7 cm. were found, the ranges being so far not exactly measured. No elements appear to have been tested for particles of a range less than 7 cm.

The method used by Rutherford and Chadwick appears to be in many respects similar to one we have been using for some time for investigating atomic fragments of very short range, from 1·5 cm. and upwards. By means of a new type of microscope of very high light-gathering power, we have counted the scintillations on a zinc sulphide screen due to particles expelled from different substances at angles of nearly 90° to that of the incident α-particles from a radium-C source, the primary radiation from the source against the zinc-sulphide being cut off by protecting screens. By giving a special shape to the source, or to the substance investigated, a maximum yield of atomic fragments could be realised. In order to test for particles of very short range, and also with the view of avoiding scattered α-particles, we have carried out these experiments in pure helium (where the range of α-particles scattered under 90° is nil), which has been kindly put at our disposal by the Bureau of Mines in Washington, U.S.A. The first results gained in this manner, which we have set out, together with a description of our method, in papers read to various physical societies in Vienna and in Sweden (for the first time on February 25, 1924, before the Deutsche Physikalische Gesellschaft in Vienna), prove that carbon, examined as paraffin, as very pure graphite, and finally as diamond powder, gives off H-particles of about 6 cm. range. Their number, which has not yet been accurately determined, is of the order 200 per 10^7 of the α-particles producing the disintegration. No scintillations due to atomic fragments heavier than the H-particles were observed from carbon at absorptions exceeding 2·5 cm.; that is, the theoretical range of the α-particles scattered at right angles from the carbon atoms. With silicon and beryllium examined by the same method, our previous results were confirmed, as H-particles were found to be discharged at right angles also from these elements. The ranges of these particles were approximately equal to those predictable from the explosion hypothesis, mentioned below.

As our present results do not seem to exclude the possibility that helium is also disintegrated, special tests will be carried out with that element.

Other experiments recently made seem to prove that oxygen is also disintegrable and gives off α-particles of 9 cm. range in the forward direction. If this result is confirmed by further experiments now proceeding, it would furnish the first example of α-particles as a product of artificial disintegration. It would also give an explanation of the particles of 9·3 cm. range from oxygen (air and carbonic acid) found by Rutherford and recently investigated by L. F. Bates and J. S. Rogers, which particles have by the latter authors been taken for long-range particles from radium-C itself (NATURE, September 22, 1923).

It is of interest to observe that the results obtained from our investigations, as well as by those of Rutherford and Chadwick, lend support to the validity of the "explosion hypothesis" for the mechanism of atomic disintegration propounded by one of us (Trans. Phys. Society of London, February 22, 1924), as an alternative to the "satellite hypothesis" of the authors last named.

Our previous statement (NATURE, September 15 and October 13, 1923), "that an expellable H-nucleus is a more common constituent of the lighter atoms than one has hitherto been inclined to believe," is also seen to be substantially confirmed by these results.

The details of our methods and of the results obtained by them are being published in the Sitzungsberichte of the Vienna Academy.

GERHARD KIRSCH.
HANS PETTERSSON.

Institut für Radiumforschung,
Vienna, April 2.

The Spectrum of Iron.

F. M. WALTERS, Jr. (Journ. Wash. Acad. Sci. 13, 1923, p. 243) has found twenty "multiplets" in the iron arc spectrum of the kind which were first found by M. A. Catalán in the spectrum of manganese (Phil. Trans. A, 223, 1922, p. 127). He also gives the Zeeman patterns of some lines. The structure of such multiplets, which are combinations of multiple terms, is governed by the restriction rules for the "inner" quantum numbers J, given by Sommerfeld and Landé (*Zeit. f. Phys.* 15, p. 189). With the help of these rules it is not difficult to find the inner quantum numbers of the terms, unknown for the rest, of which the given multiplets are combinations.

In most cases it is only possible to find relative values for these quantum numbers J, but in some cases, and fortunately in this one, there is one rule helping us to get the *absolute* values. This rule is the combination interdiction of two terms having both the inner quantum number $J=\frac{1}{2}$ (Landé, *l.c.*). It gives us the absolute values of J for the terms of multiplets wherein an initially expected spectral line is missing. As in our case the same term differences, and thus the same terms, occur in several multiplets, it is easy to obtain also with considerable certainty the absolute values of J for all the other terms. The Table 3 in the work of Landé gives us then for each multiple term the quantum numbers k and R; that means, we can find the names and the systems of the spectral terms. In some cases we need the indications of the Zeeman effect to decide between two possibilities. These Zeeman indications, moreover, give a very good confirmation for the results.

The results have shown that the twenty iron multiplets belong to a *triplet* and a *quintuplet* system. Two of the thirteen different terms are irregular; perhaps those concerning multiplets were not completely observed by Mr. Walters. The names of the terms with their quantum numbers and differences are as follows:

Triplet system:

$k=3$ $J=\frac{7}{2},\frac{5}{2},\frac{3}{2}$	d',	$\Delta\nu=390{\cdot}6,\ 252{\cdot}0$
$k=4$ $J=\frac{9}{2},\frac{7}{2},\frac{5}{2}$	f',	$=584{\cdot}7,\ 407{\cdot}6$
	f'',	$=476{\cdot}5,\ 358{\cdot}5$
$k=5$ $J=\frac{11}{2},\frac{9}{2},\frac{7}{2}$	ϕ,	$=388{\cdot}4,\ 311{\cdot}8$

Quintuplet system:

$k=3$ $J=\frac{9}{2},\frac{7}{2},\frac{5}{2},\frac{3}{2},\frac{1}{2}$	D′,	$\Delta\nu=415{\cdot}9,\ 288{\cdot}0,\ 184{\cdot}1,\ 89{\cdot}9$
	D″,	$=344{\cdot}0,\ 261{\cdot}5,\ 173{\cdot}2,\ 86{\cdot}6$
	D‴,	$=240{\cdot}2,\ 199{\cdot}5,\ 139{\cdot}7,\ 71{\cdot}1$
	D^{IV},	$=384{\cdot}3,\ 272{\cdot}6,\ 175{\cdot}2,\ 86{\cdot}0$
$k=4$ $J=\frac{11}{2},\frac{9}{2},\frac{7}{2},\frac{5}{2},\frac{3}{2}$	F′,	$=448{\cdot}5,\ 351{\cdot}3,\ 257{\cdot}8,\ 168{\cdot}9$
	F″,	$=344{\cdot}1,\ 289{\cdot}2,\ 218{\cdot}4,\ 144{\cdot}9$
	F‴,	$=292{\cdot}3,\ 227{\cdot}9,\ 164{\cdot}9,\ 106{\cdot}8$

Irregular terms:

$J=\frac{9}{2},\frac{7}{2},\frac{5}{2},\frac{5}{2},\frac{3}{2}$	x,	$=411{\cdot}2,\ 294{\cdot}4,\ 145{\cdot}4,\ 70{\cdot}2$
$J=\frac{11}{2},\frac{9}{2},\frac{7}{2},\frac{5}{2}$	y,	$=474{\cdot}9,\ 354{\cdot}3,\ 244{\cdot}8$

The twenty multiplets consist of the following combinations (numbering of F. M. Walters):

D′d' (14)	F′d' (6)	F′f'' (5)	$f'f''$ (19)
D′D″ (15)	F′D″ (4)	F′ϕ (7)	$f'\phi$ (18)
D′D‴ (1)	F′D‴ (12)	F′y (8)	$f'y$ (20)
D′F″ (13)	F′F″ (9)		
D′F‴ (16)	F′F‴ (11)	D‴D^{IV} (3)	
D′x (2)	F′x (10)	F‴D^{IV} (17)	

I have also succeeded in finding still other combinations of these terms, *e.g.* the multiplets D′y, D′ϕ, f'F″.

S. GOUDSMIT.
The University, Leyden,
February 16.

As the subject to which Mr. Goudsmit refers has recently been dealt with by other scientific workers, it is due to him to direct attention to the date of his letter. The delay in publication is due to the fact that the proof sent was not returned, and a duplicate afterwards posted reached us only on April 11.

ED. NATURE.

The "Bleeding" of Cut Trees in Spring.

IN the correspondence on the above subject in NATURE of April 5, p. 492, Prof. Priestley refers to me by name, though he honours me unduly with the title of Dr., to which I can lay no claim. In a small way I have been engaged in tree-planting for the last twenty years, and often go among my saplings in winter with long pruners, cutting out double leaders and other ill-placed shoots. The profuse bleeding from cut surfaces of the sycamore and birch has struck me so forcibly that now, unless their pruning is completed by February, I refrain from dealing with them until foliation commences, imagining that the loss of so much saccharine sap must be detrimental. The bleeding has not been noticed in the case of other forest trees commonly grown in this country. No doubt there are other species of maple (Acer) and birch (Betula) that bleed readily on being injured in early spring. In fact, I feel fairly certain that the Norway Maple (*Acer platanoides*) does so, and of course the Sugar Maple of Canada is a stock example put to economic use. Recently I tried some young English Maples (*Acer campestre*), but they failed to respond; though a sycamore adjoining bled at once on being cut. It would be interesting to ascertain how far this spring bleeding is characteristic for the above two genera.

In Cumberland the spring so far has been abnormally dry—in fact, an official drought has been registered—and this, I think, is affecting the bleeding. On two occasions recently, sycamores growing on a dry bank have been compared with others situated in the damp hollow below; the former on being cut exuded no sap, while the latter bled immediately.

There *may* be something in Mr. C. W. Folkard's idea of sunshine stimulating the flow. I have a feeling that way myself, but no systematic observations to offer with which to support it. Prof. Priestley dismisses this idea with the suggestion that the sunshine will raise the soil temperature and so increase root activity. But if it can be shown that as a rule a sunny day following a dull one provokes bleeding which was not in evidence before, then surely this sunshine can scarcely have had time to warm appreciably the soil so as to augment root activity. The extra heat will, however, make itself felt at once on the shoot system.

It is to me not a matter of surprise to learn that the sugar in the exuded sap of the sycamore is sucrose and not hexose. The little we know regarding the rôle of sugars in the flowering plants (Angiosperms) suggests that the plant, when calling upon its carbohydrate reserves (starch, inulin, etc.), is in a hurry to get these transformed into cane sugar (sucrose) for circulatory purposes. Though no reserve carbohydrate (raffinose and gentianose are somewhat exceptions), when hydrolysed by enzyme, or acid, yields sucrose, yet, strange to say, in the living plant it is this sugar which accumulates and none of those (such as maltose, glucose, fructose, mannose) resulting from the hydrolysis. The same may apply to the photosynthesis of carbohydrate in the green leaf. The sugar actually first liberated may be sucrose, though a hexose phase may be passed through rapidly, without any appreciable accumulation of this class of sugar. Accepting the view that sucrose is the form in which the plant desires its carbohydrate for active purposes, a reason for this can be advanced. It may be that for metabolic processes the plant requires its hexose in the nascent state, and this can be readily obtained by the inversion of sucrose on the spot.

John Parkin.
The Gill, Brayton, Cumberland,
April 10.

The Theory of Hearing.

In Nature for April 22, 1922, I pointed out that the resonance theory of the action of the cochlea is flatly contradicted by a simple experiment. When a card is held against the teeth of a rapidly revolving toothed wheel, a tone is heard from the blows of the teeth on the card. According to the resonance theory the first impulse of air from the card falling on the ear sets all the fibres of the basilar membrane in vibration. The second impulse hinders some of them from continuing to vibrate and favours certain others. The third stroke kills off still more vibrations, and the following strokes reduce to quietude all the fibres except that one whose natural period coincides with the period of the strokes. When the wheel is speeded up or down, the strokes come with different intervals between each two strokes. The first stroke will set the whole membrane in motion; the second stroke may favour some fibres and oppose others; the third stroke will favour quite a different set; the fourth stroke will in turn oppose and favour other sets; and so on. Moreover, each succeeding stroke will start a movement in any fibre that may have been brought to a standstill. The result would be an irregular jangle of all the fibres.

None of the extensions or modifications of the Helmholtz theory affords the slightest chance of escape from the conclusion that the series of strokes at steadily changing intervals must be heard as an irregular jangle of tones. This is exactly what does not occur; the series is heard as a single tone of steadily rising or falling pitch—a direct and unanswerable proof that the theory is false. Exactly the same experiment is made all the time during speech. The tone of the voice is never constant at a definite pitch for even the briefest instant; it rises and falls incessantly. Yet the melody of speech is a quite clear affair; we do not speak in a jangle of tones. Recent researches show that the same is true of song. The singer may think he is maintaining his tone on a given note, but the records show that his voice rises and falls around a note and does not remain on it.

One writer in reply to my previous statement said that we must look at the obvious, namely, that the fibres of the basilar membrane resemble a stringed instrument and therefore must resonate like one. To him it is obvious that we have a kind of piano-like apparatus in each ear. This is exactly what is not obvious. The experiment I have mentioned is certainly obvious and conclusive. Microscopic sections of the basilar membrane with its broad fibres not differing greatly in length, all imbedded in a membrane and forced to move together with no chance of vibrating singly, are obvious facts. The position of this delicate membrane in a mass of liquid with no power to move against it is equally obvious. The delicacy of these bands with no chance of their being tuned under tension makes a resemblance to piano strings certainly not obvious. All the experiments to illustrate the Helmholtz theory have been made with hard materials such as brass resonators or steel wire, and the exciting vibrations have been the vibrations of tuning forks maintained at a constant pitch.

The natural answer to an attack on a theory is a demand for one that will be more in accordance with the facts. Several attempts have been made, but it cannot be said that any have succeeded. On the present occasion I wish to give an extremely brief summary of the fundamental theses of a new view of the action of the cochlea, leaving the detailed treatment for another occasion.

The first thesis is that the basilar membrane and its fibres are non-elastic tissues, and therefore are non-vibratory bodies which have no resonance periods of their own.

The second thesis is that the basilar membrane is imbedded in a liquid and must follow its movements exactly at every point. No part of the membrane can execute any vibration independent of or in opposition to the liquid surrounding it.

The third thesis is that the labyrinthine water moves differently at every different point for any movement at the stapes, owing to the shape of the canal of the cochlea and to the fact that the movements of the two halves influence each other across the basilar membrane.

The fourth thesis asserts that for every movement of the stapes there is a movement of deformation of the basilar membrane.

The fifth thesis asserts that the nerve end organs distributed over the basilar membrane serve to transmit a picture of the deformation to the brain. The linear movement at the stapes thus becomes a spatial deformation in three dimensions at the basilar membrane, and this elaborate picture is what is transformed into nerve impulses and into a brain process.

The sixth thesis asserts that any analysis of the auditory sensations that may occur is made in the brain and not in the cochlea. The waves of the vowel "ah" arrive at the stapes as linear movements, at the basilar membrane as surface deformations, and at the brain as nerve combinations. If the vowel "ah" is heard to consist of several tones, this analysis must occur in the psychic centres. It is quite correct to say that any such analysis—if we wish to call it an analysis—is a matter of the imagination. A person hearing the vowel "ah" may imagine that he hears certain tones in it that distinguish it from the vowel "oh," which he hears to have other tones. That this is imagination is indicated by the fact that all observers get different results for their mental analyses. That it is pure imagination is proved by the fact that the physical curve of a vowel cannot be analysed into vibrations corresponding to tones. As the result of many years of work at analysing vowel curves I am quite prepared to show that a vowel may be represented as the sum of a number of frictional sinusoids whose periods are independent of one another—that is, not necessarily in harmonic relations,—with logarithmic decrements of independent values. For such curves the Fourier analysis has no physical meaning, and no other form of analysis has been or—as can be shown mathematically—can be devised that will analyse it. The analysis of a vowel into component tones can be shown to be mathematically and physically impossible. This disposes of the Helmholtz assumption of such an analysis in the ear.

The deformation theory that I have outlined above may seem revolutionary and incredible. One part of it at least was anticipated by Waller, who made the following statement, with no explanation of how he arrived at it: "We may regard the basilar membrane as a long, narrow drumhead, repeating the complex vibrations of the membrana tympani, and vibrating in its entire area to all sounds—although more or less in some parts than in others—giving what we may designate as acoustic pressure patterns between the membrana tectoria and the subjacent field of hair-cells. In place of any analysis of the consonation by any particular radial fibres, it may be imagined that varying combinations of sound give varying pressure-patterns, comparable to the varying retinal images of external objects" ("Introduction to Human Physiology," 1896). By a kind of divination—or rather common sense—based presumably on the "obvious" facts of human histology, he arrived at the only view that is consonant with the facts—a view that has been utterly neglected in favour of the Helmholtz theory.

I cannot forbear noting the analogy to the Helmholtz theory that the vowels are composed of tones harmonic to the voice tone, which pushed aside the Willis theory that the vowels consist of independent vibrations aroused by puffs from the larynx. After years of oblivion the Willis theory has been shown to be true for German vowels by Hermann and for English vowels by myself (see NATURE, January 13 and 20, 1921). Yet there are people who still maintain the discredited theory. There must be some psychological reason deep in the unconscious that forces people to believe in and cling to the series of numbers 1, 2, 3, etc., that lie at the basis of the harmonic theory of the vowels and the resonance theory of hearing.

E. W. SCRIPTURE.

University of Vienna.

Photoelectric and Selenium Cells.

THE prevailing impression, expressed by Dr. Slater Price in NATURE of March 8, p. 351, that photoelectric cells are less trustworthy than selenium, is, we believe, due to the practice of using gas-filled cells with the active surface sensitised by the discharge in hydrogen. Cells prepared with untreated surfaces of the alkali metals in a high vacuum are perfectly trustworthy instruments; they show neither time-lag nor fatigue, and can readily be prepared differing in absolute sensitivity by a factor of not more than two. They are, of course, less sensitive than the Elster-Geitel gas-filled cells, but their sensitivity is ample for all ordinary photometric purposes with very simple electrical measuring apparatus. If greater sensitivity is required, we believe that it may be attained far more conveniently by amplification outside the cell than by amplification within it—unless possibly when the cells are required for astronomical purposes and the whole apparatus has to be mounted on the telescope.

Cells of the type we advocate are made in these laboratories for our own purposes. We have supplied some in response to outside inquiries, and have no doubt that arrangements could be made to supply them generally if sufficient demand were forthcoming.

THE RESEARCH STAFF OF THE G.E.C., LTD.

Research Laboratories of the General Electric Company, Ltd., Wembley, April 7.

The Three-Colour Process and Modern Painting.

VERY much so-called art, defended as "modern," appears to represent an irrational cult, having no more justification than the chaotic mental concepts which are so often opposed to the progress of science. There is, however, a method of painting which at first seems anarchistic and contrary to Nature, but on closer examination (metaphorically) or more distant examination (literally) appears significant and interesting, amounting to a real discovery in art. Just now we have on exhibition at the University of Colorado a collection of paintings by Robert A. Graham, a rather well-known artist in the United States, in which the method referred to is employed. At close range the pictures appear to be merely arrangements of spots of colour, mainly red, yellow, and blue. It seems impossible that they can represent anything natural. But at the distance of ten feet or so an extremely soft and natural landscape appears. The method is exactly the same, essentially, as that of the three-colour photographic process, which in the hands of experts gives us pictures exquisitely true to Nature, or to our optical impression of Nature. Such prints (*e.g.* in Taylor's "Monograph of British Mollusca") are so natural that I have found myself at times using a lens to make out finer details, of course with the result of losing the whole impression. These matters may have been fully elucidated and appreciated in artistic circles, but they throw light on our process of vision, and are of interest to scientific men as well.

T. D. A. COCKERELL.

University of Colorado, Boulder.

Discovery and Research.

IN the leading article in NATURE of April 5, on "Medical Research in Great Britain," dealing with the Report of the Medical Research Council for the year 1922–23, you seem to regard it as a sign of failure that the Report contains no record of a first-class medical discovery made in Great Britain during the year in question. The work of the Medical Research Council does not need support from me, but I am concerned that NATURE should adopt the exaggerated idea of the merit of 'discovery' which is held by the 'man in the street.' Every discovery, however important and apparently epoch-making, is but the natural and inevitable outcome of a vast mass of work, involving many failures, by a host of different observers, so that if it is not made by Brown this year it will fall into the lap of Jones, or of Jones and Robinson simultaneously, next year or the year after.

One or two examples will illustrate my point. Bayliss and I once had the good fortune to make a 'discovery'! It was of no practical use to any one, but a source of much gratification to ourselves, since it seemed to open up a new chapter in our knowledge of the body. But there were at that time half a dozen workers skating along the edge of the discovery, and it is difficult to comprehend why, for example, Wertheimer and Lepage did not take the one further step which would have made them and not us the discoverers of *secretin*.

The same thing applies to other discoveries which have been of paramount importance for the welfare of mankind. Ross's discovery of the transmission of malaria by mosquitoes had been prepared by the work of many other men on the part taken by insects in conveying disease both to men and to the lower animals. If Ross had never lived, it is improbable that this great discovery would have been deferred by more than a few months or years. Similarly, the preparation of *insulin* by Banting and Best, an admirable piece of work, is but the last step of an arduous journey, in which hundreds of workers have taken part. In the history of insulin, the greatest achievement was probably that of Minkowski, when he showed that diabetes could be produced by extirpation of the pancreas. If tradition may be believed, this discovery was due to an accidental observation of the old laboratory servant, who tasted some crystals left on the floor of the laboratory by the evaporation of urine voided by the operated animals, and found them sweet. The actual discovery of insulin waited, however, forty years, until an easy and accurate method was devised for the estimation of sugar in small quantities of blood. A dozen workers were on the track. Banting and Best, coming in late, but with the freshness and ardour of youth, arrived first.

I believe that NATURE has urged the desirability of a sum of money being set aside by Parliament for the reward of 'discovery.' I contend that any such sum should rather be used as consolation prizes for the many able scientific workers who have never made a discovery.

Discovery brings its own reward. Not only is there the joy of being first on a virgin peak—a joy that every mountaineer hopes to experience at least once in his lifetime—but, if the discovery is of a nature to be appreciated by the public, it brings in its train Royal medals, K.C.B.'s, Nobel prizes, and academic distinctions of all sorts, not to mention the plaudits of the daily press.

The Medical Research Council has no need to concern itself with 'discoveries.' All it has to do is to ensure that the growing tree of knowledge is dug round and pruned, dunged, and watered. The fruit will come in due season, and will fall to the lot of some one who may or may not have been assiduous in the labour of cultivation. The Report of the Council shows that this, its function, is being wisely and diligently carried out; and we servants in the House of Science cannot but approve of its efforts to facilitate our work. ERNEST H. STARLING.

University College, W.C.1,
April 12.

Note.—I see that, in this week's NATURE, you have the distinguished support of Sir Ronald Ross in what I venture to regard as your heresy. Rewards such as he advocates might, like charity, do much good to the giver; they would not, I think, influence in the slightest degree the output of 'discovery.'

April 19. E. H. S.

PROF. STARLING considers that a body like the Medical Research Council has to concern itself only with digging round, pruning, manuring and watering the plant of knowledge. It depends a great deal upon the person who carries out these operations. Instead of ripe fruit the result may be a lot of stray leaves. We cordially agree that discoveries in science are usually the end stage of many trials by many people, but the one who ultimately succeeds where hundreds have failed is surely entitled to a good deal of credit.

THE WRITER OF THE ARTICLE.

Monazite Sands and other Sources of Thoria.

MAY I solicit space for a rejoinder to "The Writer of the Article," who replied to my letter published in NATURE of February 16. The explanation given does not satisfy me. The Imperial Institute discovered thorium in some samples sent from Ceylon. I am not trying to minimise the importance of this discovery, but I object to the statement that "the discovery of the monazite sands of Ceylon has destroyed the former German monopoly based on Brazilian material." According to the Imperial Mineral Resources Bureau's monograph, Ceylon produced monazite concentrates in commercial quantities for the first time in 1918. These quantities, as the table published with my first letter will show, were too small to make the slightest difference to the general position. In the years 1905, 1906, and 1907, thorianite was exported from Ceylon to the extent of approximately 9 tons, 2½ tons, and ½ ton respectively. One hundredweight of thorite was exported in 1905. The total production of thorium-bearing minerals from Ceylon up to and including 1921 comes to 208 tons. Within the same period India produced 76 times this total. The German monopoly was destroyed by the Government of India's action during the War in refusing to allow foreigners to work mineral concessions in India.

The Imperial Institute was instrumental in directing attention to the possibility of finding monazite in India, but to take all the credit not only for its discovery, but also for the breaking up of the German monopoly in thorium-bearing minerals, seems to me an extravagant attitude. Valuable deposits of oil shale have recently been discovered in Somersetshire. Had I the same temperament as "The Writer of the Article," I might write to the Geological Survey of Great Britain suggesting that they should try the Lias deposits of the Midlands and claim the credit for any subsequent discovery of oil shales in that part of England. E. H. PASCOE.

Geological Survey of India, Calcutta,
March 13.

APPARENTLY Dr. Pascoe would not dissent from the statement that the Ceylon discovery, of which the influence does not admit of simple statistical proof or disproof, struck the first blow at the German monopoly. The term "monazite sand" was used, in accordance with commercial practice, to include other minerals yielding thorium.

THE WRITER OF THE ARTICLE.

Philosophical Magazine, 1914–1923.

I WOULD like to direct attention to the case of Prof. Chwolson, of Petrograd, the author of the great text-book on physics. He is now working on the new edition of the last volume, and for consultation purposes is in urgent need of the *Philosophical Magazine*, 1914–1923.

Prof. Chwolson (who is seventy-one years of age) finds it impossible to get copies of the magazine in Petrograd, and is quite unable to purchase it. I should be very grateful, therefore, if any readers of NATURE could see their way to let me have the above for despatch to Petrograd. Possibly my Committee might be prepared to pay a small sum, if any possessor of the magazine was unable to present it.

B. M. HEADICAR,
Hon. Secretary.

Universities' Library for Central Europe,
London School of Economics,
Clare Market,
London, W.C.2, April 3.

Sir William Crookes.

THERE is an error in my "Life of Sir William Crookes" which I should like to rectify. I stated that the disagreement between Crookes and the late Sir James Dewar over a method of producing colloidal silver led to the bankruptcy of Crookes's eldest son Henry, who had discovered the method while working under the direction of Sir James Dewar.

I now find that there was no such bankruptcy, but that Henry Crookes voluntarily resigned his work at the laboratory and set up independently, with considerable eventual success.

In justice to the three men, who are now dead, I should be glad if you could publish this correction in your journal. E. E. FOURNIER D'ALBE.

The Hermitage, Portsmouth Road,
Kingston-on-Thames,
April 13.

The Radiation of Light.[1]

By Prof. H. A. LORENTZ, For. Mem. R.S., University of Leyden.

ONE of the lessons which the history of science teaches us is surely this, that we must not too soon be satisfied with what we have achieved. The way of scientific progress is not a straight one which we can steadfastly pursue. We are continually seeking our course, now trying one path and then another, many times groping in the dark, and sometimes even retracing our steps. So it may happen that ideas which we thought could be abandoned once for all, have again to be taken up and come to new life.

These remarks are well illustrated by the way in which at different times physicists have represented to themselves the way in which light is produced and radiated. The two contending views, the emission theory or the corpuscular theory of light, developed by Newton, and the undulatory theory proposed by Huygens, perfected afterwards by Young and Fresnel, and newly shaped as the electromagnetic theory of light by Clerk Maxwell, are well known. I should now like to point out how these two theories, however widely different their principles may be, were interwoven in Newton's mind, and how it is well possible that they will be interwoven again in the physics of the future.

When one reads Newton's "Optics," one cannot doubt that, when he speaks of a ray of light, he always thinks of a stream of small corpuscles emitted by a luminous body and moving along in straight lines, so long as they are not acted upon by some deflecting force. The phenomenon of diffraction, as we call it now, that had been discovered by Grimaldi and which Newton carefully examined experimentally, I mean the phenomenon that the shadow of a thin wire, for example, is wider than it would be in the case of undisturbed rectilinear propagation, was attributed by Newton to certain repulsive forces with which the wire acts upon the rays of light when they pass along its surface at a very small distance.

The reflection and the refraction of light were likewise considered as due to forces which act upon the corpuscles of a ray when they come near the surface of separation of two media, like air and glass or water. Newton expressly states that the corpuscles must not be conceived to be reflected by the *individual* molecules of the body on which they impinge. If we could see the molecules, we should find the surface to be very rough, and it would be clear that their individual actions can scarcely lead to a regular specular reflection. For this reason Newton supposes that the corpuscles of light are acted upon, not by the molecules separately, but by parts of the bodies containing a great number of them. This does not prevent us from supposing the actions in question to be appreciable at very small distances only. If they were sensible up to one ten-thousandth of a millimetre, for example, and if you had a corpuscle situated at half that distance from a polished plate of glass, then, since the structure of the glass is very fine grained with respect to the distance in question, the corpuscle would be acted upon by an immense number of molecules, and the discontinuities would not make themselves felt, so that it would be as if we had a perfectly smooth surface.

[1] Discourse delivered at the Royal Institution on Friday, June 1, 1923.

The forces of which I am speaking are comparable to those that were introduced much later by Laplace in the theory of capillarity. A corpuscle in the interior of a body will experience equal forces in all directions, so that there will be no resulting force and the particle continues its way with a constant velocity. It is only in a very thin layer extending on both sides of the surface of separation, that there will be a resulting force, due to the unequal attractions, or perhaps repulsions, which the two media exert on the corpuscle. For reasons of symmetry the resulting force is perpendicular to the surface of separation, and therefore, whether the corpuscle be reflected into the first medium or allowed to continue its way in the second, the component of the velocity in the direction of the surface will remain unchanged. From this you can easily deduce the law of reflection. As to that of refraction, a simple diagram (Fig. 1) shows that, if the velocity along the surface AB is the same before and

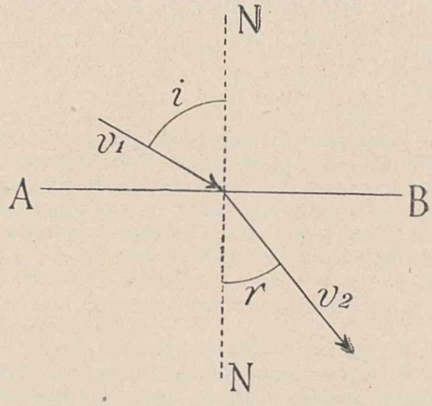

FIG. 1.

after the refraction, the sines of the angles which the ray makes with the normal NN, the angle of incidence i and the angle of refraction r, will be inversely proportional to the velocities, say v_1 and v_2, with which the corpuscles move on the two sides of the surface; indeed, since the component of the velocity along the surface is $v_1 \sin i$ on one side, and $v_2 \sin r$ on the other, its constancy requires that

$$\sin i : \sin r = v_2 : v_1.$$

We shall therefore have found the well-known law of refraction, namely, the constancy of the ratio between the two sines, if we suppose v_1 and v_2 to have definite values, whatever be the angle of incidence. Now, if the first medium is air, or rather the ether, we shall suppose v_1 to have a definite value, at least for rays of a particular colour, on account of the way in which light is emitted. Once taking for granted this constancy of v_1, we can assure ourselves of that of v_2 by taking into account that the passage of a corpuscle from the interior of the first medium to the interior of the second will be accompanied by a definite change in the value of the potential energy, this value being in each medium the same for all positions of the corpuscle and whatever be its motion. By the law of the conservation of energy the change in the kinetic energy of the corpuscle must be equal and opposite to that of the potential energy; thus, the difference $v_1^2 - v_2^2$ must be the same in all cases, and the constancy of v_2 follows from that of v_1.

I shall dwell no longer upon the further development of the corpuscular theory, but I must now point out that Newton also had the notion of vibrations, and even of waves, that are propagated in a medium. He was led to this by his experiments on the colours of thin plates, which we now attribute to interference, and which he examined very carefully for the case of the thin layer of air contained between a plane surface of glass and a surface that is slightly convex. Here we have the phenomenon generally known as Newton's rings. Suppose the light to be homogeneous and the incidence to be normal. Then, both in the reflected and in the transmitted light, you will see a number of alternating bright and dark rings, the dark rings in the transmitted light having the same diameters as the bright ones in the reflected light. This means of course, what is quite natural, that, at a thickness of the layer for which a great part of the light is reflected, only a small part is transmitted, and conversely.

The experiment shows that, of all the rays that enter at the front surface of the layer, some will be reflected at the back surface and others not, and that this depends on the thickness of the layer, the distance between the two surfaces. Further, that there is a certain periodicity in this. Now, since two rays, one of which is reflected at the back surface and the other not, must obviously be more or less different, Newton supposes that, after having passed the first surface, a ray or a corpuscle is in alternating states, *fits*, as he calls them, *of easy reflection and easy transmission*. But I think I had better give this in his own words:—

What kind of action or disposition this is; whether it consists in a circulating or a vibrating motion of the Ray, or of the Medium, or something else, I do not here enquire. Those that are averse from assenting to any new Discoveries, but such as they can explain by an Hypothesis, may for the present suppose, that as Stones by falling upon Water put the Water into an undulating Motion, and all Bodies by percussion excite vibrations in the Air; so the Rays of Light, by impinging on any refracting or reflecting Surface, excite vibrations in the refracting or reflecting Medium or Substance, and by exciting them agitate the solid parts, of the refracting or reflecting Body, and by agitating them cause the Body to grow warm or hot; that the vibrations thus excited are propagated in the refracting or reflecting Medium or Substance, much after the manner that vibrations are propagated in the Air for causing Sound, and move faster than the Rays so as to overtake them; and that when any Ray is in that part of the vibration which conspires with its Motion, it easily breaks through a refracting Surface, but when it is in the contrary part of the vibration which impedes its Motion, it is easily reflected; and, by consequence, that every Ray is successively disposed to be easily reflected, or easily transmitted, by every vibration which overtakes it. But whether this Hypothesis be true or false I do not here consider. I content my self with the bare Discovery, that the Rays of Light are by some cause or other alternately disposed to be reflected or refracted for many vicissitudes.

Let me add that, in order to account for the fact that light falling on a surface of glass is partially reflected and partially transmitted, Newton assumed that fits of easy transmission and easy reflection exist already in the incident rays before they reach the surface. He supposed *these* fits to have been impressed on the rays already in the act of emission itself; in fact he went so far as to imagine something like vibrations to go on in the source of light. Query VIII near the end of the book begins with the words:—

Do not all fix'd Bodies, when heated beyond a certain degree, emit Light and shine; and is not this Emission perform'd by the vibrating motions of their parts?

So there was much of vibratory or undulatory theory in Newton's ideas, though he seems never to have thought, as Huygens did, of the ray itself consisting in a propagation of waves. In Query XVII he again compares the ray of light falling on the surface of some substance to a stone thrown into stagnant water.

As is well known, the conclusion that the sines of the angles of incidence and refraction would be *inversely* proportional to the velocities of propagation became fatal to the corpuscular theory. The undulatory theory required that the two sines be *directly* proportional to the velocities of propagation, and when, about a century ago, the velocity of light in water could be measured, the result was in full agreement with the wave theory. I can briefly state the facts by saying that the index of refraction of water is about 4/3. The velocity of light in water ought therefore to be 3/4 of that in air according to the undulatory theory, and so it was found to be, but the corpuscular theory requires that it should be greater than the velocity in air, namely, 4/3 times that velocity.

There now came a period during which the wave theory reigned supreme, until in these last ten or twenty years physicists have been led to ideas, not exactly the same as Newton's, but still more or less similar to the notions of the corpuscular theory.

The beginning of it was that, on the basis of the electromagnetic theory, a beam of light was recognised to possess a certain momentum, comparable to that of a moving ball. For the ball the momentum is given by the product mv of the mass and the velocity, and when we attribute to the beam of light a certain momentum, say an amount Q of it, we simply mean to say that the beam has the same power of setting bodies in motion as a body would have, for which the product mv has just that value Q.

The existence of momentum in a beam of light is shown by the pressure of radiation that was predicted by Clerk Maxwell, and observed and measured first by Lebedew and afterwards by E. F. Nichols and Hull. Let us consider this question for the case of a beam of light falling normally on a perfectly reflecting mirror, and let us compare the explanation by the undulatory theory, and the explanation that could be given by a follower of Newton, if there were one in these times. For the sake of simplicity I shall suppose that we hold the mirror in position by applying to it a certain force. If we can calculate that force we shall also know the pressure on the mirror, to which it is equal.

In the experiments the pressure has been compared to the energy which, in the beam of light, falls on the mirror in unit time, the two quantities being proportional to each other. Now, according to both theories, the momentum which falls on the mirror has its direction reversed, and the ratio in question will be equal to that of twice the momentum of the light that reaches the surface during a certain time, to the energy of that same light. In the corpuscular theory this would be the ratio of $2\,mv$ to $\frac{1}{2}\,mv^2$, or $4/v$; thus, when c is the speed of light, $4/c$. On the undulatory theory the ratio between the momentum and the energy of a beam is that of 1 to c, by which the result becomes $2/c$. Thus, for a beam of a given intensity, the pressure would be different in the two theories, in the undulatory theory half only of what it would be on the other view, so that here again we have a crucial experiment. The measurements have clearly decided in favour of the wave theory.

Our neo-Newtonian would have to own himself defeated by this, if he had been taught classical mechanics only, and had never heard of the changes that have been brought about by the theory of relativity. If he has studied this latter theory there is an escape for him; indeed, he can point out triumphantly that the values which relativity assigns to the momentum and the energy of any moving system are such that our last result $2/c$ holds in all cases. Only, this appeal to relativity would imply that the corpuscles become widely different from what they were originally thought to be. According to relativity dynamics, a thing moving with the speed of light and having a finite mass, however small it may be, would have an infinite momentum and an infinite energy. Therefore, since the pressure has a finite magnitude, a corpuscle must be something with no mass m at all, but which, nevertheless, when moving with the velocity c, has a finite energy and momentum. By these assumptions the corpuscles become much like the so-called light quanta of modern theory, to which I should now like to refer.

The word "quanta" is used by physicists in two different senses. In some cases we mean by it no more than definite amounts of energy of radiation, the magnitude of which is proportional to the frequency n, or number of vibrations in unit of time, so that it can be represented by hn, where h is a constant. In this form the idea originated with Planck, who used it in the problems of heat radiation, and after whom the constant h is generally called. In Bohr's theory of spectral lines these minute amounts of energy play a fundamental and most important part; one of his assumptions being that light is not emitted in quantities of any magnitude, but in a greater or smaller number of full quanta that are radiated successively, one at a time.

It ought to be remarked that in this form the notion of quanta has nothing that is very startling or mysterious. If a tuning fork is made to vibrate by taps of a definite intensity, the fork being allowed to lose all its energy before it receives a new blow, we shall have emission of "sound quanta." We can imagine without difficulty that similarly in a source of light the energy is measured out in small but finite portions of a fixed magnitude.

However, this does not always suffice. There are phenomena from which, if we had to judge by them solely, we should certainly infer that the energy of a quantum not only has a definite amount, *but also remains confined to a very small space.* In this way one has been led to the idea of "concentrated quanta," which may well be said to be Newton's corpuscles in a modernised form.

The phenomena to which I alluded are those of photo-electricity. When light of a suitable frequency is let fall on a plate of a properly chosen substance, electrons are set free, and it has been found that the energy of each of these electrons is equal to the quantum for the light which we use. This can be easily understood if the quanta are confined to small spaces, so that the electron can catch at once a whole quantum, whereas, if a quantum is spread out over a considerable extent, it is very difficult to see how an electron is to get hold of it. So the phenomena of photo-electricity seem to speak in favour of some corpuscular theory.

Let us, in order to make this clearer, suppose that the sensitive plate is first placed at a small distance from the source of light, and is then removed to a distance a hundred times as great, so that the intensity of the light or the total energy that falls on the plate in a certain time becomes 10,000 times less. Observation shows that the number of electrons liberated from the plate also becomes 10,000 times less, but that they are ejected with exactly the same velocity as before. This would be very natural if we could adopt some form of corpuscular theory, either the old or the modernised one. Then it would be clear that the number of corpuscles striking the plate has diminished in the ratio I mentioned, but that each individual corpuscle can do just what it did at the smaller distance, for the velocity has not been altered, and the corpuscle or the concentrated quantum has lost none of its properties.

On the contrary, when there are no concentrations, when, in spreading out, the energy becomes more and more dilute, we should expect that, at a certain distance, the light becomes too feeble ever to liberate an electron.

So it would seem that we really want concentrated quanta. But now, having recognised this, we have to face a very serious difficulty, a difficulty that hangs as a heavy cloud over this part of physics. Indeed, the existence of narrowly limited disturbances of equilibrium is absolutely irreconcilable with the principles of the undulatory theory as they are embodied, for example, in Maxwell's equations of the electromagnetic field. According to these equations, a disturbance of the state of the ether can never remain confined within a space of constant magnitude; around each point that is reached by the disturbance there is a propagation in all directions, and so there is always the tendency to a lateral expansion that becomes manifest in the phenomena of diffraction. It is true that, when our openings are wide in comparison with the wave-length, we may have beams of light that are rather sharply defined over a certain length, but if we go far enough along the beam we shall ultimately notice an unlimited expansion. When, for example, parallel rays are made to pass through an opening of one centimetre in diameter, we observe an illuminated circle of the same magnitude with a rather sharp border on a screen at a distance of some metres, but if the screen is removed to a distance of 100 kilometres, there will be a badly defined patch of light extending over something like half a metre. Or, again, take the case of a disturbance initially confined within a spherical space a centimetre in diameter. At some later instant it will be found in a shell of this thickness, bounded by two concentric spheres which both expand with the speed of light. By properly choosing the distribution of the disturbance in the initial sphere, you have it in your power to produce different distributions in the expanding shell, but you can never prevent the disturbance from occupying ultimately a very considerable part of the spherical wave.

One might object that these are mostly theoretical inferences and that we must never swear by a theory, not even by Maxwell's. Let me therefore conclude by pointing out that, so far as we can see now, the hypothesis of concentrated quanta is directly in contradiction with observed facts, namely, with what is seen in the phenomena of interference.

It is known that bright and dark interference fringes can never be produced by means of two different, mutually independent, sources of light; we explain this by the want of all coherence between the vibrations in one source and those in the other. Now, the elementary acts of emission, in each of which a quantum is radiated, must certainly be incoherent; they may take place in different atoms, and there is not the least reason why there should be any connexion between what goes on in one atom and in another. Hence, when we observe an interference phenomenon, *one* quantum taken by itself must be able to produce it, and this will enable us to draw some conclusions concerning the extension of a quantum in different directions.

In certain experiments made with highly homogeneous light, interference fringes have been observed, produced by rays the paths of which differed by more than a million of wave-lengths. This means that there was a regular succession of more than a million of waves, and, since all these waves must be contained in one quantum, the length of a quantum in the direction of propagation must have been more than, say, 50 cm. That the lateral dimensions must be no less considerable is shown by the influence which the aperture of an optical instrument has on the quality of the images, and consequently on the resolving power. Let L (Fig. 2) be the objective glass of a telescope, a "perfect" lens from the point of view of geometrical optics, so that, if there were no diffraction, the rays R coming from a distant star would converge exactly towards the focus F. In reality this can never be; on the plane V there will be an illuminated spot of a certain extent, and if we want to have this spot small, so that there is a sharply defined image of the star, we must use a large lens. As a matter of fact this is one of the advantages of the great modern telescopes.

Let us conceive the opening of the telescope to be divided into two parts, say of equal areas, a central circle L_1 and a ring L_2 around it. If, by means of a screen with a circular opening, we reduce the aperture to the part L_1, the image of the star becomes less sharp; a point P at a small distance from F, which remains dark when the full aperture is used, may now be illuminated, the light disappearing again when the screen before the lens is removed. The explanation is, of course, that the vibrations which P receives from L_1 are counteracted by opposite ones coming from the part L_2. So, the fact that a large opening actually has the effect on the quality of the image which we expected from it, shows that there is interference between vibrations reaching the lens at different points of its surface. According to what we saw, these vibrations must belong to one and the same quantum, and we may therefore conclude that the lateral extension of a quantum is comparable to the size of the objective.

The remarkable experiments by which Prof. Michelson has been able to measure the diameter of some stars allow us to push the argument still further. In his apparatus a beam carrying four mirrors, 1, 2, 3, 4, was placed in front of the opening of the telescope, the mirrors 2 and 3 occupying places within the opening, whereas 1 and 4 were outside the opening, on opposite sides of it. The mirrors were adjusted in such a way that two beams of rays coming from the star entered

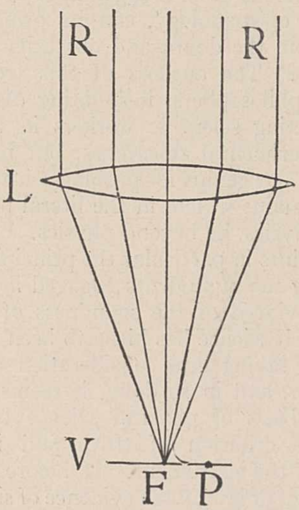

Fig. 2.

the instrument, one being reflected by the mirrors 1 and 2, the other by 4 and 3. The fact that in these circumstances interference fringes appear in the field of view proves that a quantum must reach from one of the outer mirrors to the other. The distance between these mirrors was no less than 6 metres.

The discrepancy between these estimates of the size of a quantum, according to which it would be too big to enter our eye, and, on the other hand, the notion that it is small enough to be captured by a single electron, is certainly very wide. Yet the laws of the two classes of phenomena about which we have reasoned, the phenomena of interference and those of photo-electricity, are so well established that there can be no real contradiction between what we deduce from one class and from the other; it must after all be possible to reconcile the different ideas. Here is an important problem for the physics of the immediate future. We cannot help thinking that the solution will be found in some happy combination of extended waves and concentrated quanta, the waves being made responsible for interference and the quanta for photo-electricity.

Science and Philosophy.

By Prof. H. WILDON CARR.

I.

THERE are men of science who are undisguisedly alarmed and greatly discouraged at the tendency of the new mathematical and physical theories to plunge science into metaphysics. The new principles seem to be throwing doubt on the basis of science and confusing the pure positivity of its method. The value of the scientific work of the mathematicians who have formulated the principle of relativity is unquestionable and unquestioned, but their abandonment of the common-sense basis of scientific reality seems to many a high price to pay for an advance in theoretical knowledge. The fear goes deeper. Twenty-five centuries of philosophical speculation have failed to produce any general agreement among philosophers on the fundamental principles of metaphysics. If physical science is to be dragged in as arbiter to decide problems of epistemology, can its own principles be kept free from the doubt and obscurity which invade metaphysics? The authors of this trouble are not speculative philosophers, insinuating dialectical paradoxes, upsetting scientific workers in their straightforward experimental researches, but men of science with a particular genius for pushing scientific investigation into domains which, in the literal meaning of the term metaphysics, lie beyond physics.

On two points in particular the principle of relativity is disquieting many students engaged in research who are still convinced of the soundness of the assumptions on which science has hitherto been based. First, it insists on taking into consideration the conditions of knowledge, and in so doing it seems to be undermining the basis of physical science by challenging the absolute criterion of truth and introducing a scepticism of the instrument. If, before we can affirm a scientific fact or law on the evidence of simple observation, we must inquire what knowing and its conditions are, then it seems that we abandon for good and all the positivity of science as truth about reality, for the authority of reason depends on its absolute disinterestedness. Secondly, the principle of relativity presents the physical universe as mediately constructed from individual experience and not as immediately revealed to it. If the universe is constituted of systems of reference, and if each system though in relative movement is at rest for the observer attached to it, and if this is a condition of the observation of natural phenomena, then it seems that the positivity of science is made impossible by the very nature of physical reality, that the leaven of subjectivity has corrupted the whole conception of a pure object of physics, and there is introduced a scepticism of the foundation of science.

When each of these consequences of the new principle is examined in its full significance, however, not only is all ground of alarm removed, but also a far surer positivity of science is discovered. The fact is that until the twentieth century, and the coming of the principle of relativity, physical science never has built on impregnable rock, but always on improvised foundations.

I propose in the present article to examine only the second of these two points, that, namely, which concerns the mathematical principle of relativity and what is frequently described as its idealist interpretation. In a second article I will deal with the still more fundamental point, the problem how the intellect, which is a product of biological evolution, can yet furnish a criterion of scientific truth.

It is not the principle of relativity itself, as Lorentz and Einstein employ it in determining the subject-matter of physics, but a corollary of that principle, which seems to infect the basis of physical observation with scepticism. It is the implication that the conception of a common universe, independent of particular viewpoints of observation, a conception which is held to be an indispensable presupposition of science, is not imposed on the observer from without but constructed by him from within. According to the principle of relativity the physical universe consists of mass systems in movement, and the movements of these systems are not absolute but relative to one another. Consequently, it is a condition of observation that any observer attached to any one of these relatively moving systems, if he would measure and co-ordinate the phenomena of the universe, must *experience* his own system as a system at rest, as a system the movement of which is always zero. From this it clearly follows that observers attached to different systems have different experience and actually co-ordinate the universe from different viewpoints. It would seem, therefore, that there can be no possibility of agreement between them in the meaning of a common objective reference, such as has hitherto always been attributed to physical science. This seems to introduce subjectivity into science in a peculiarly insidious form, to turn reality into appearance, to reduce objectivity to illusion. The new science, in departing from the simplicity of the old, seems of necessity to be sacrificing the objective reference which constitutes its positivity.

There are two alternative ways, and only two, of interpreting the fact that individual subjects of experience think there is a common universe independent of their perceptions and ideas, to which their perceptions and ideas refer. One way is to assume that a physical world does exist in its own right and that in some way by its influence on receptive minds it reveals itself in the form of representations or ideas. This is the ordinary assumption of common sense, and hitherto it has been the accepted presupposition of physical science. The other way is to account for the idea by the internal activity of individuals and what is common in their experience, and to interpret the concept of the physical universe as a function of modes of experience and as a product of trans-subjective intercourse. This theory has been put forward in various forms by philosophers dissatisfied with the common-sense view. The difficulty of the first view is that the relation of knowing to being is utterly incomprehensible and invites the challenge of scepticism. The difficulty of the second is that it can find no means of assuring that the physical world is not wholly, what it must be partly, an illusion. These are the alternatives, and the principle of relativity, moved by a purely scientific necessity, not by a logical consideration, or by a speculation of philosophy, has decisively rejected the first and adopted the second. When the reason for this choice is understood, physical science may seem to have had to sacrifice its primitive simplicity, but it will be found to have established itself on a much firmer foundation.

For some centuries of human history no one has been able to doubt that the earth moves, rotating diurnally on its axis, translated annually in an orbit round the sun. Yet though it never occurs to any one to doubt this, no one from the time of Copernicus onwards has been able to change the belief that the earth moves from an intellectual induction into an actual immediate sense experience. No one feels the earth move. We may safely affirm that no one ever will. But the reason is not easy to understand. In fact, the case is unique. In all ordinary terrestrial experience it is to feeling we appeal. We may be ignorant, or at least imagine ourselves ignorant, whether it is the train we are in or the landscape outside which is moving, but when we have decided we can always acquire the direct positive feeling of translation. In the case of the earth we cannot. It is not difficult to suggest reasons to account for the inability. It may be a product of evolution with a definite survival value. There is, however, a closely related fact, which recent scientific experiments have demonstrated, and which we cannot account for in this or any similar way. We now know that not only can we not feel the earth's movement, but also we cannot discover or demonstrate it by any of the effects we should expect it to have on our observations of physical phenomena. It has none of these effects—so far as they are concerned the earth is at rest. It is true that we can see an effect of the earth's rotation in the tracing of the movement of Foucault's pendulum, just as we can see the effects of the earth's translation in Tycho Brahe's mappings of the planetary courses, but we cannot discover the earth's movement by taking it into account as a factor in our measurements of velocities.

This is a positive discovery, and it is a scientific necessity that we should know why. It was to meet this very case that the principle of relativity was formulated. It is the absolute condition of the possibility of a scientific co-ordination that we should experience the system to which we are attached and by reference to which our measurements are made as at rest. In fact, were we earth-dwellers able to feel the earth moving or become aware of its movement in the effect on our observations, then no measuring-rod we could devise would measure space and no clock would mark uniform time. It is, therefore, a condition of physical science that the earth-dweller be insensible to the earth's movement.

No one is likely to dispute that it is a need of scientific interpretation of experimentally demonstrated fact which has led to the principle of relativity. What distresses many men of science is the loss of simplicity. The Newtonian scheme had formidable difficulties, but they were purely metaphysical, and science has prided itself on an easy way with metaphysics. This has been to follow the method which Auguste Comte taught, to recognise the phenomenal character of scientific reality, proclaim the arrival of the positive stage, and relegate metaphysics to the unknowable. Modern science has declined to humble itself and confine itself within self-imposed limitations, and it is enjoying its reward. Comte told us we could never know what the stars are made of, and we never should have known had science been content with his method. The science of the twentieth century is on a far surer basis, just because it has not foolishly thought to secure itself by fencing itself in and excluding metaphysics. The new principle calls on us no longer to accept physical reality as a direct revelation, but to construct our conception of it by metaphysical inquiries based on the conditions of observation.

The principle of relativity has given new meaning to the aphorism with which Bacon begins his "Novum Organum." "Man, as the minister and interpreter of Nature, does and understands as much as his observations on the order of Nature, either with regard to things or the mind, permit him, and neither knows nor is capable of more." Science has its limitations and its boundaries, but these are neither imposed from without nor surveyed from an independent vantage-ground. They are determined from within. The old conception was too simple. If for our scientific generation physics is dependent on a difficult mathematical work of intellectual construction, and if the relativity implied in this constructive reality can never be overcome, it is this very relativity which delivers science from scepticism by enabling truth to be absolute.

(*To be continued.*)

Obituary.

SIR WILLIAM MACEWEN, F.R.S.

SIR WILLIAM MACEWEN, professor of surgery in the University of Glasgow, died after a short illness on March 22, in his seventy-sixth year. He was born at Rothesay in the Isle of Bute, June 2, 1848, the youngest son of a large family which had to be reared and educated on the limited income which fell to his father, a mariner-trader. He became a student of medicine in the University and Royal Infirmary of Glasgow in 1865, this being the year in which Lister applied for the first time an antiseptic dressing in the old Infirmary. He graduated in medicine in 1869, just as Lister was moving from Glasgow to succeed Syme in the chair of clinical surgery in Edinburgh. He remained in Glasgow to become house-surgeon to Lister's lieutenant and disciple—George Macleod.

Macewen was thus reared in the cradle of Listerism, and from his student days realised to the full that a new era had dawned upon surgery. As he grew into manhood he developed the attributes one would like to ascribe to an ideal Highland chief—a tall, erect, well-proportioned figure, a long and finely balanced head, clean-cut but ample features of face, and a thrustful, vigorous, masterful attitude of mind. He did not shine in examinations, for he was one of those who must see and handle facts before they can be absorbed and used as part of a mental outfit. For him books—although he afterwards came to write them—were inferior sources of learning; he went through life amassing and teaching his own stock of knowledge.

In 1875, at the age of twenty-seven, Macewen became assistant surgeon in Lister's old Infirmary, being appointed full surgeon in 1877, and there he remained for fifteen years—the period of his greatest fertility. In 1892 he succeeded Sir George Macleod as professor of surgery—an appointment which necessitated the transference of his clinical work from the wards of the Royal to those attached to the chair in the Western Infirmary. It was the custom for a newly elected professor to apply for these wards; Prof. Macewen let the managers of the Western Infirmary know that it was their duty to invite him, otherwise he would remain in his old wards in the Royal Infirmary. Neither in the business affairs of life nor in those of surgery would he compromise. Even before his election to the chair, honours began to flow in upon him: in 1890 his own University conferred on him the degree of LL.D.; in 1895 he became F.R.S.; in 1900 he was made an honorary fellow of the Royal College of Surgeons of England; Oxford, Dublin, Liverpool, and Durham conferred degrees on him. The honour of knighthood came to him in 1902.

On Lord Lister's death in 1912 Macewen became, in the eyes of his fellows, the leader amongst British surgeons. In the application of results obtained by experimental inquiry to the art of surgery, and for daring, resolution, and judgment in opening up new fields to surgical endeavour, he had only one rival—the late Sir Victor Horsley, his junior by nine years. Both were men of marked individuality, striving for reform, impatient of orthodoxy, propagandists, seriously minded. In his methods of inquiry Macewen was a disciple of John Hunter, while Horsley was the finished product of the modern physiological laboratory. One cannot help speculating as to what the effect would have been on the individuality of these two leaders in surgery if they had received a public school education and later passed on to Oxford or Cambridge.

During his early years at the Royal Infirmary, Macewen opened up, or greatly extended, four branches of surgery. In these days it was generally held that the mother substance of a bone was its periosteum or covering membrane, and that if a defect in a bone was to be made good, the repairing graft had to be cut from living periosteum. It is true that both Hunter and Goodsir had proved that bone was a living tissue, but in 1880, when Macewen first sought to reproduce a new humerus in the arm of a boy by planting grafts of living bone, he was moved by inferences he had drawn for himself. He cut grafts from the leg-bones of six healthy boys to form the seeds of a new arm-bone for a seventh boy, and succeeded. Lister's discovery made such a feat possible. Macewen's interest in the physiology of living bone remained with him all through life. He summed up the results of his experiments and observations in a monograph, "The Growth of Bone," published in 1912. He realised, as John Hunter had done a century earlier, that the most instructive and magnificent of all experiments in the growth of living bone are those which Nature produces annually in the antlers of stags.

In Macewen's earlier years at the Royal Infirmary, surgeons all over the world were seeking for better methods for the treatment of two common forms of bodily disablement. In the first place, there were deformities of the limbs such as knock-knee and flat foot. In 1877 Macewen restored the transverse axis to the knee-joint by chiselling through the lower end of the thigh bone, restoring alignment and treating the limb as if it had been the seat of an accidental fracture. Lister's discovery made such a practice safe. It all seems and sounds so simple, yet no one thought of the method until Macewen put it in practice. The other problem to which Macewen gave his attention was that of the operative treatment of hernia, so prevalent in large industrial centres—such as Glasgow. Lister had shown that if his methods were followed, hernial sacs could be safely opened up, their contents replaced, and the defect in the body wall made good. In 1886 Macewen devised and applied one of the most successful methods of restoring the parts concerned in hernia to their normal condition.

In 1873, when Macewen was waiting in Glasgow for practice to grow up around him, there appeared Sir David Ferrier's work on localisation of function in the brain. Macewen was the first surgeon to apply the new knowledge to the diagnosis and treatment of brain conditions. In 1876 he diagnosed, and wished to relieve by operation, an abscess in the frontal lobe of the brain of a boy. The operation was refused. At the post-mortem examination it was found that Macewen's diagnosis was right, and that his proposal might have given relief and recovery. In 1878 he diagnosed and removed a tumour pressing on the frontal lobe. His attention to brain surgery guided him to his greatest discovery. He found that disease of the middle ear was the commonest of all sources of danger to the brain. He demonstrated that the infection which gives rise to abscesses in the cerebrum and cerebellum, and to the choking of the great veins which issue from the interior of the skull with septic clots of blood, issues from primary centres of disease in the middle ear. He thereby opened one of the largest and most beneficent of all our fields of modern surgery. This part of his life's work he began in 1883; ten years later, 1893, he published the results of his experience in "Pyogenic and Infective Diseases of the Brain and Spinal Cord." It was while pursuing these problems in brain surgery that he prepared and published an "Atlas of Head Sections."

These are the chief things Macewen accomplished in surgery, but many minor endeavours also stand to his credit. He showed that a surgeon's fear of the lung collapsing if the chest is opened was unjustified; he successfully resected a whole lung. He was one of the first to try "intubation of the larynx" to keep the breath-way open, instead of resorting to tracheotomy. He invented his own surgical tools and made his own catgut.

Macewen rendered many public services. In the War he was consulting surgeon for Naval Forces in Scotland; he gave his time and knowledge for the relief of limbless men; from disabled men in workshops of the Clyde he raised a band who became experts in the difficult art of fashioning artificial limbs. He was an ideal president for congresses of medical men. He presided over the International Association of Surgeons which met in London in 1921; he was president of the British Medical Association in 1922; in 1923 he was the ambassador chosen to represent this Association at the Australasian Medical Meeting in Melbourne. He returned from his visit to Australia full of health and vigour to resume the work of his chair and wards, when pneumonia, supervening on an attack of influenza, brought a very full and vigorous life to a sudden and lamented end. His love for his native island in the Firth of Clyde endured to the last; he found succour and refreshment on the farm he owned and maintained there. There was in him not only a reincarnation of the grandeur and imperiousness of a Highland chief; there was in his life's work something of the fire, zeal, and dourness of the Scottish Covenanter.

DR. NELSON ANNANDALE, C.I.E.

THE death of Dr. Nelson Annandale, Director of the Zoological Survey of India, in Calcutta on April 10, at the comparatively early age of forty-eight, is a severe loss to science and to Indian zoology in particular. The eldest son of Prof. Thomas Annandale, the famous Edinburgh clinician, he was educated at Rugby, Balliol, and Edinburgh, taking his B.A. at Balliol in 1899; he was awarded the D.Sc. from Edinburgh in 1905. Before joining the Indian Museum as Deputy Superintendent in 1904, he was Research Fellow in Anthropology at the University of Edinburgh, and had already made a reputation as an investigator into the anthropology and natural history of the Malay Peninsula. Between 1900 and 1905 he published numerous papers on the biology—he always took biology to include anthropology—of the Malay Peninsula and the islands off Scotland, including "The Faroes and Iceland: A Study in Island Life," and with H. C. Robinson and others, "Fasciculi Malayenses," the classical work on Malayan natural history.

Two years after joining the Indian Museum Dr. Annandale was elected Superintendent on the retirement of Lieut.-Col. A. W. Alcock, and it is noteworthy that in ten years he succeeded in convincing the Indian Government of the importance of zoology, and had the gratification of seeing his department raised to the rank of an Imperial Survey in 1916, with himself as its first Director. He was a prolific writer, and it is hoped that a bibliography of his numerous publications will appear in the Records of the Indian Museum, the journal founded and edited by him.

At one time or another Annandale had worked on most groups of zoology, especially herpetology, ichthyology, entomology, and malacology, and was known as an authority on the freshwater sponges, polyzoa, and cœlenterates, and on the barnacles. The diversity of his published work is largely the result of the fact that he always had one main problem in mind: the elucidation of the fresh- and brackish-water fauna of British India, a subject in which he has done for India—one may say the East—what Wood-Mason and Alcock did for the marine fauna. An enthusiastic collector, he was primarily an ecologist, his taxonomic work being done largely because it was necessary for the consideration of his biological studies, or because he felt that it was necessary to arrange the large collections under his care, a work in which he only had the assistance of three scientific officers.

In the last few years Annandale was especially interested in the biology of Asiatic lakes and in the adaptations of animals to their environment, and contemplated a book on convergence and the editing of a monograph of the River Ganges, in which it was proposed to deal with this ancient river from all points of view. Only recently the present writer compiled for him a bibliography of the work done on the fresh- and brackish-water fauna of India from 1912–22, which is practically only a partial indication of his own energy and versatility.

A widely read man, Dr. Annandale was acquainted with most branches of science and was deeply interested in art, and it is typical of him that in reply to a question as to what he was interested in he said: "Everything that is interesting." These qualities, his geniality, and his satirical humour made him a popular and conspicuous figure at the Asiatic Society of Bengal, on the council of which he had served since his arrival in India, while last year he served as its president. He had the true scientific spirit, never seeking honours, but it is gratifying to observe that he was awarded the C.I.E. in 1923, and only this year had been recommended by the council for election to the Royal Society.

Indian zoology as a whole has felt his stimulating influence, and much valuable work, such as that of Stephenson on Oligochætes, Brunetti on Diptera, Hora on hill-stream fishes and Batrachia, to mention only a few, owes its inception to him. Towards juniors he was particularly encouraging and indulgent, and I think there are many who, like myself, are deeply indebted to him for his constant encouragement and advice, and a generous interest which often took a practical form. Dr. Annandale never enjoyed good health in India, and one feels that he has paid with his life for his devotion to his subject. In him we have lost a man at the zenith of a brilliant career, and it is sad that he was not spared to see a satisfactory conclusion to the work he instituted and developed.

CEDRIC DOVER.

PROF. R. HITCHCOCK.

WE have received information of the death last November, at Baltimore, of Prof. Romyn Hitchcock, who did much to further the study of microscopy. Born in 1851, he studied science at the Cornell University and Columbia School of Mines, and his subsequent career was one of varied activities. He was assistant professor of chemistry, Lehigh University, 1872–74; professor of chemistry and toxicology, Chicago Homeopathic Medical College, 1876–77; judge of awards for the United States on several of the juries at the Fisheries Exhibition, London, 1883; curator in the National Museum, Washington, 1883–86; and professor of English, Government School, Osaka, 1886–88. While at the last named he was in charge of the photographic work of the United States eclipse expedition, 1887. After his return from Japan, he spent a year in China as United States Commissioner in connexion with the World's Columbian Exhibition. Prof. Hitchcock's literary activities covered a wide range, and dealt with automatic telegraphy, mining, photography, and Japanese archæology. In later years he published papers on botanical subjects in the Bulletin of the Torrey Club, and at the time of his death he was investigating the staining reactions of the living nucleus of the vegetable cell.

Prof. Hitchcock was the first editor of the *American Quarterly Microscopical Journal* and of the *American Monthly Microscopical Journal*, and did much to forward microscopy in all its branches. His death will be deeply regretted by numerous friends and correspondents in many parts of the world. R. T. H.

The death has been announced of Canon Joseph Thomas Fowler, scholar and antiquary, at the age of eighty, on March 22, at Winterton, Lincolnshire. After receiving his education, partly at home, partly at Wakefield, Canon Fowler qualified for the medical profession, but later determined to enter the church. He became a member of the University of Durham, devoting himself particularly to the study of theology and Hebrew. After a period as a curate at Houghton-le-Springs, and as precentor at Hurst Pierpoint, he returned to Durham in 1870. He became Hebrew lecturer and held a number of other University appointments. Canon Fowler had inherited his antiquarian taste from his father and grandfather. After his election as F.S.A. in 1867, he became a frequent contributor to *Archæologia*. On his return to Durham, his activities in antiquarian research were much extended both in scope and in volume. His printed books published by the Surtees Society alone numbered eleven. He wrote constantly for *Notes and Queries*, and was the author of innumerable occasional articles in newspapers, magazines, and the proceedings of antiquarian societies. He left Durham in 1917, having received the honorary degree of D.C.L. from his University in 1894, and the gift of an honorary canonry of Durham Cathedral in 1897. His remaining years were occupied with the transcription of the volumes of Lincoln Chapter Acts and other documents of historical importance.

We regret to announce the following deaths:

Prince Roland Bonaparte, for many years president of the French Geographical Society and a free member of the Paris Academy of Sciences, on April 14, aged sixty-five.

Prof. G. A. J. Cole, F.R.S., professor of geology at the Royal College of Science for Ireland and Director of the Geological Survey of Ireland, on April 21, aged sixty-four.

Mr. H. Deane, a distinguished botanist who was president on two occasions of both the Royal and the Linnean Societies of New South Wales, and also a well-known engineer who was the first member of council for Australia of the Institution of Civil Engineers, on March 12, aged seventy-seven.

Surgeon-Colonel R. J. Reece, C.B., Senior Medical Officer, Ministry of Health, and formerly president of the Epidemiological Society of London, on April 20, aged sixty-one.

Current Topics and Events.

On Wednesday last, H.M. the King opened the British Empire Exhibition at Wembley, thus inaugurating the largest and most comprehensive display of the resources and activities of the Empire which has ever been organised. The many striking features of the Exhibition have already been made familiar to most by the daily press in articles and illustrations; in addition to the gigantic Palaces of Industry and Engineering, there are the Government Pavilion housing the Home Country exhibits, the Pavilions erected by the various Colonies and Dominions Overseas, and lastly, though perhaps in some ways more important than any of the others in the significance of the business carried on within it, the Conference Building with its five halls. The deliberations which will go on within the walls of the Conference Building almost daily throughout the course of this summer can scarcely fail to be of prime importance for the promotion of progress and research. Of more immediate interest to readers of Nature are the scientific exhibits in the Palace of Industry and the Government Pavilion. As we have stated in earlier issues, these are divided roughly into two groups, the physical and biological sciences being cared for by a committee of the Royal Society, while the pure chemistry exhibits have been arranged for by the Association of British Chemical Manufacturers. In both cases, efforts have been made to avoid the "museum" type of exhibit, which, excellent though it may be and instructive to those who will ponder over the descriptions, is scarcely suited to the needs of perhaps the majority of those who will visit the Exhibition. Something capable of arresting attention is obviously necessary, and to this end demonstrations of apparatus and experiments have been arranged. The application of research to industry is, of course, shown by practically every exhibit at Wembley, but we may perhaps refer to that arranged by the Ministry of Agriculture and Fisheries to demonstrate the importance of research in various branches of agriculture. Eight main groups of exhibits are shown which tell a continuous story. They deal with animal breeding and nutrition, veterinary science, soils, plant breeding, horticulture, plant pathology, agricultural machinery and agricultural economics. In each case the exhibits have been set up by the Research Institute specialising in the particular branch, and qualified guide lecturers explain the exhibits at stated intervals daily. Descriptions of all the scientific exhibits have been prepared and are available in the Exhibition. In future issues, we hope to deal with specific aspects presented by the Exhibition.

A conference on Science and Labour in the Modern State is to be held at the British Empire Exhibition, Wembley, on Friday, May 30, and Saturday, May 31. The conference is being organised by a joint Committee consisting of representatives of the British Science

Guild and of the National Joint Council—a body representing the Trades Union Congress, the Labour Party, and the Parliamentary Labour Party. Progressive industry depends upon creative science; and labour is directly interested in the development of both. The forthcoming conference is intended to provide a common platform for free and open discussion of the best means of promoting national well-being through the alliance of these three forces of science, invention, and labour—in government, in industry, and in education. It should, therefore, perform a very useful service, and promises to be one of the most valuable to be held during the Exhibition. There will be five meetings, namely, in the morning, afternoon, and evening of May 30, and in the morning and afternoon of May 31. The main subjects of these meetings, and some topics which may be discussed appropriately under them, are as follows—(1) *Science in Government*: (*a*) In Parliament (both Houses); (*b*) In Administration; (*c*) In the Army, Navy, and Air Force Councils. (2) *Relation of Scientific Research and Invention to Progressive Industry*: (*a*) Scientific research; (*b*) Industrial research; (*c*) Raw materials and power agents; (*d*) Inventions and patents; (*e*) Rewards for discovery and invention; (*f*) Creation of new industries. (3) *Co-operation of Labour and Science in Production and Administration*: (*a*) Occupational reward, permanency, and efficiency; (*b*) Improvements in organisation, i. Mechanical, ii. In human co-operation; (*c*) Machinery and labour-saving methods; (*d*) National organisation of, i. Transport, ii. Fuel and Power; (*e*) Provision for displaced workers. (4) *Science and the Human Factor*: (*a*) Psychology in the workshop; (*b*) Vocational guidance and selection; (*c*) Industrial fatigue; (*d*) Workshop hygiene; (*e*) Unhealthy trades; (*f*) Preventive sickness. (5) *Science in Educational Organisation*: (*a*) The special education of, i. The Workman, ii. The Manager; (*b*) Works schools; (*c*) Adult education; (*d*) Passports on the Educational Highway.

Much has been written recently in the daily Press about the "invisible rays of destruction" invented by Mr. H. Grindell-Matthews, whose work in connexion with the control of distant moving mechanisms is fairly well known. On April 15, he was the principal guest at the annual luncheon of the Foreign Press Association. In a speech, he explained how during the War he devised a power-driven boat controlled by a search-light beam which fell on a "selenium" pilot on the funnel of the boat. This was in connexion with relays which set in motion its machinery. It was possible in this way to operate different parts of the mechanism of the distant boat and even to discharge a gun. Mr. Grindell-Matthews stated that he now had means of transmitting power from one point to another, either or both of which might be rapidly moving, and added that he did not attempt to answer in what direction this new application of power was tending. Possibly "armies would be wiped out in a few seconds." He was tempted to hope that it would make war impossible. It will be seen that whatever the "invisible ray" may be, its method of application has still to be developed. We remember how sanguine some engineers were during the War that they could short-circuit the magneto coils of aeroplanes with a high-frequency beam and thus bring them to earth. We also remember the proposals made to transmit high-frequency power over considerable distances by utilising the conducting layers of the upper atmosphere. Neither of these suggestions has yet reached the practical stage.

In a recent issue of the *Morning Post*, Dr. Cuthbert Christy writes a carefully reasoned letter advocating a reorganisation of the Imperial Institute "to constitute a nucleus for a great African intelligence bureau, headquarters for investigation, and an educational centre for all things African." He considers that the Institute is not the failure it is commonly held to be, but is the victim of the circumstance that, in the natural course of development, the Dominions (as distinct from the Colonies) no longer need the assistance which the Imperial Institute rendered to them in former years. Dr. Christy suggests that, as so great a part of the work of the Imperial Institute is now concerned with the tropical African colonies, the Institute (including a large part of the exhibits in the collections) is admirably suited for an African Institute devoted to the development of British tropical Africa. It is probable that Dr. Christy's plan would not completely solve the difficulty, but his letter adds support to the opinion that the Imperial Institute needs but reorganisation to enter upon a prosperous future. It would seem that the first consideration is an agreement as to the scope of the future activities of the Institute, and this decision should indicate the sources of the necessary income. These points settled, the primary need is a governing body in full sympathy with the work and active on its behalf. If, then, the necessary reorganisation is carefully and fairly effected, wise internal administration should ensure the future of the Imperial Institute.

The rapid increase in the number of the electric power circuits in Great Britain has brought prominently forward the question of their interference with telegraphy and telephony. Methods of measuring the extent of this interference and methods of obviating the troubles caused by it have been devised both in America and in Europe. Unfortunately, these methods apply only to special cases, and new types of problem are continually arising. For example, in broadcasting, the speech has often to go through a long telephone line where it is sometimes affected by tramways, railways, and power and electric lighting circuits. The paper, therefore, read by Mr. Bartholomew, of the General Post Office, to the Institution of Electrical Engineers on April 10 was a very timely one. He stated that the troubles were caused by both electromagnetic and electrostatic induction, and he dealt with the balancing of both power and telephone circuits. He considers that all that is to be expected from a telephone engineer is to protect his system from interference by telegraph and telephone circuits. Interference in Great Britain is generally caused by the earth currents in a three-phase system or by the harmonics in current- and electromotive-force-waves. It rests with the designers of electric generators to make machines which produce pure sine waves. Some suggestions were also made as to the use of "filters" to eliminate the harmonics from power waves. In our opinion the question is also one for the mathematician. Approximate solutions can be obtained for the electromagnetic interference when the effects of capacity are neglected. Similar solutions can also be obtained when the electromagnetic effects are neglected. What is wanted is a solution when both effects are taken into account. To do this engineers will have to learn the use of Maxwell's electrostatic coefficients, and will also have to attempt to calculate their values for cylindrical conductors.

It will be seen on reference to our column "Early Science at the Royal Society" (p. 625) that under the date April 28, 1686, there is recalled the circumstance of the presentation to the Society of Newton's "Principia" in manuscript form. This occurred during the presidency of Samuel Pepys. Later, at a meeting held on May 19, 1686, it was ordered that the manuscript be printed forthwith in quarto "in a fair letter," and that Newton be written to to signify the Society's resolution and to ask his opinion as to the print, volume, cuts, etc. Edmund Halley undertook the proud duty of communicating at once to Newton the intention of the Society. He wrote, "I am intrusted to look after the printing it, and will take care that it shall be performed as well as possible, only I would first have your directions in what you shall think necessary for the embellishing thereof, and particularly whether you think it not better that the schemes should be enlarged, which is the opinion of some here." The details of the ensuing controversy in which Hooke was involved are, of course, well known. Newton tells Halley that, in the papers sent, there is not one proposition to which Hooke could pretend. That "Philosophy is such an impertinently litigious Lady that a man had as good be engaged in lawsuits as have to do with her. I found it so formerly and now I have no sooner come near her again but she gives me warning." His ever affectionate friend and correspondent replies that he is heartily sorry that any disgust should make him think of desisting in pretensions to a Lady whose favours he had so much reason to boast of. Halley printed the "Principia" at his own expense, the book appearing in 1687. As a matter of fact, the Royal Society, having just been at the expense of printing Willughby's "History of Fishes," was without funds, and, but for Halley's timely intervention, the issue of the "Principia" might have been indefinitely delayed.

The first conversazione of the Royal Society this year will be held at Burlington House on Wednesday, May 14, at 8.30 p.m.

The Ministry of Agriculture of the Government of Northern Ireland requires a male assistant in seed testing to work under the direction of the head of the Ministry's seed-testing and plant disease division. Applications should reach the Secretary, Ministry of Agriculture, Belfast, by April 30 at latest.

A Librarian and Assistant-Secretary is required by the Linnean Society of London. Some knowledge of natural history and languages is necessary. Applications for the post should be made upon a form obtainable from the secretary of the society, Burlington House, Piccadilly, W.1.

According to *Science*, an aquarium, the gift of John G. Shedd, chairman of the board of Marshall Field and Co., is to be erected at a cost of 400,000*l*. in Chicago. The building, as now planned, is to be 300 feet long, one story high, surmounted by a dome. It will be situated on the lake front near the Field Museum.

Sir William Bulmer has presented to Bankfield Museum, Halifax, the Ling Roth collection of books, papers, MSS., etc., relating to primitive spinning and weaving. This collection is very rich in illustrations of native spinning and weaving in various parts of the world. As Bankfield Museum specialises in primitive textile tools the gift is an appropriate one.

Through the courtesy of Prof. Palazzo, director of the Central Office of Meteorology and Geodynamics at Rome, we have received the first reports of the recent eruption of Stromboli. It began at 3.34 a.m. (2.34 a.m. G.M.T.) on March 28, with a very strong explosion and abundant emission of ashes, lapilli, and larger blocks, that covered the surrounding country and destroyed several vineyards. The exact position of the crater could not be determined owing to the enormous columns of dense smoke that enveloped the island, and the vapour that arose from the lava descending towards the sea. The eruption continued in full strength until the afternoon of March 31, when the emission of smoke was greatly diminished.

The annual meeting of the Iron and Steel Institute is to be held on May 8-9. The newly elected president, Sir William Ellis, will deliver his presidential address on the first day of the meeting, and the Bessemer Medal will be presented to Prof. A. Sauveur, professor of metallurgy and metallography at Harvard University. The afternoon session and the greater part of the second day of the meeting will be devoted to the reading and discussion of papers. Further meetings announced are on June 3-6, at the Empire Mining and Metallurgical Congress, to be held at the British Empire Exhibition at Wembley, and the autumn meeting in London on September 4-5.

A Banting Research Foundation has been established to commemorate the work of Dr. F. G. Banting, Mr. C. H. Best, and those who co-operated with them in the discovery and development of insulin, and a campaign is to be conducted in Canada and the United States with the object of raising at least 100,000*l*. The funds collected will go partly to support the Banting and Best chair of medical research in the University of Toronto, and partly to establish a fund to assist scientific workers "who may have proposed definite problems of medical research," whether they are working in the University of Toronto or elsewhere. A distinguished board of trustees, under the chairmanship of Sir Robert A. Falconer, president of the University of Toronto, has been appointed to administer the Foundation.

THE Report of the Bristol Museum for 1923 records the gift by Drs. Frederick and Eveline Jacques of a collection of Lepidoptera from Kula Lumpur. It is hoped that the room containing the geological collections, which has long been closed for reconstruction, will soon be reopened to the public. The only known perfect copy of Millerd's map of Bristol (1673) was found among prints sent to Great Britain from a town in northern Italy, and was obtained and presented to the Museum.

IN the Report of the National Museum of Wales for 1923 a large amount of work is recorded, especially under archæology, where field-work is prominent. The Botanical Department also is organising field-work by way of completing a geographical series representing all the counties of Wales and the Welsh Borders, and of mapping on an ecological basis the whole vegetation of the Principality. By collecting, by donation, and by purchase, 11,000 specimens were added to the herbarium during the year; these included the large collection of British flowering plants, bryophytes, and lichens formed by Mr. A. R. Horwood, late of the Leicester Museum. The public exhibits have been selected to illustrate the general scope and diversity of botany; they have included living plants, aquatic plants in aquaria, and experiments with plants. Other departments are working on similar lines.

MESSRS. SCOTT, GREENWOOD AND SON, 8 Broadway, Ludgate Hill, London, E.C.4, have in preparation a new edition of "The Handbook to the Technical and Art Schools and Colleges of the United Kingdom." Forms setting out the details required for the Handbook can be obtained from the publishers by secretaries and registrars of schools and colleges.

THE most recent catalogue (No. 234) of Messrs. W. Heffer and Sons, Ltd., 4 Petty Cury, Cambridge, should be of interest and value to many readers of NATURE. It gives the titles of about 3000 second-hand works on mathematics and physics, 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; also of complete sets of scientific journals on sale by the booksellers issuing the catalogue.

Our Astronomical Column.

THE LUNAR ECLIPSE OF FEBRUARY 24.—M. A. Danjon, Director of Strasbourg Observatory, is specially interested in the study of the illumination of the eclipsed moon, and observed the recent eclipse with the aid of a doubly refracting apparatus in the eyepiece; by turning this, he could place the brightest part of one image against the darkest part of the other, and so could measure the intensity of the shadow. In the 1921 eclipse the latter was comparatively bright; in the recent eclipse it was much darker, a fact noted also by others. Mr. R. Waterfield (Journ. Brit. Astron. Assoc., February) considered that even the penumbra was darker than usual. M. Danjon has applied numerical measures of intensity, and found that 3′ inside the edge of the umbra the density was 4·0 as compared with 3·5 in 1921; at the edge the figures were 3·02 (1924) and 2·90 (1921).

M. Danjon associates these variations with the sunspot cycle. If this is the case, the effect probably arises from a correlation between that cycle and the average transparency of the lower layers of the earth's atmosphere. He states that he predicted a change from bright eclipses to dark ones about the middle of 1923, that being probably about the commencement of the new cycle of activity.

ORBIT OF MELLISH'S COMET, 1917 I.—This was one of the most brilliant comets in recent years, the nucleus being compared with Venus. It was not visible for long in the Northern Hemisphere, but was well observed in the Southern, the limiting dates being March 19 and June 24, and the number of observations 186. Mr. C. J. Merfield early detected sensible departure from a parabolic orbit, finding a period somewhat less than two centuries.

Mr. Sten Asklöf has published his investigation of the definitive orbit in Band 18, No. 7, of the Archives of the K. Svenska Vetenskapsakademien. He finds the following elements:

$$T = 1917,\ \text{Apr. } 10{\cdot}67418 \text{ G.M.T.}$$

$$\left.\begin{aligned} \omega &= 121^\circ\ 17'\ 47'' \\ \Omega &= 87\ \ 31\ \ 47 \\ i &= 32\ \ 41\ \ \ 2 \end{aligned}\right\} 1917{\cdot}0.$$

$$\log q = 9{\cdot}279185.$$

$$\text{Period} = 145 \text{ years.}$$

The uncertainty in the period is estimated as about a year.

There are no previously recorded comets that can be identified with this one, but there are two with similar periods: 1862 II., Tuttle (connected with the Perseid meteors), 119·6 years, and 1889 III., Barnard, 128·3 years.

STONYHURST OBSERVATORY IN 1923.—The annual report of Stonyhurst Observatory for 1923 follows its usual lines, including meteorological, magnetic, seismographic, and sun-spot records. The year was a wet one, the rainfall being 63½ inches (average 47 inches). There were six magnetic disturbances classed as "very great," two of them being separated by one solar rotation. The only sun-spot of considerable size was seen on January 4 in latitude +6°. There were several spots in high latitudes (new cycle), but they were all small. Father Cortie notes, however, that they were magnetically active. A new Milne-Shaw seismograph has been installed, but was unfortunately not available for the two chief disturbances of the year, February 3 and September 1. The record of these was incomplete, owing to the boom adhering to the stop at the limit of its traverse. On September 15 a large party of the members of the British Association visited the Observatory. There were also visits from the Burnley Literary and Scientific Club, and the Blackburn Literary Club.

Research Items.

Totemism in the Upper Nile Province.—In vol. 6, Pt. 2, of *Sudan Notes and Records*, Mr. H. C. Jackson, in the course of some notes on the Nuer, describes the totemic beliefs of these people and offers an interesting suggestion as to their possible origin. The Nuer are at times subject to considerable privation in the matter of food, although they can abstain from eating for a day or two, and, on occasion, even as much as five days without, apparently, any serious inconvenience. Birds are not eaten except in extremity, and then only in secret; but if a man is related to or descended from a twin, he will on no account and in no circumstances eat a member of the feathered world. In several other instances, reverence for members of the animal world, such as snake, viper, fish, crocodile, etc., is connected with twin birth. It is suggested, therefore, that Nuer totemism, instead of being associated with conception, as suggested in the theory put forward by Sir James Frazer, is connected with the custom of giving the child a name which commemorates something that happened at the time of its birth. In several cases this involved a special relation between the bearer of the name and the object from which the name was derived.

Cancer and Tar.—The only important advance which has been made in recent years in discovering the cause of cancer has been the steady accumulation of evidence implicating long-continued irritation and injury as the chief precedent, culminating in the demonstration that cancer of the skin may be produced experimentally, in mice with a fair degree of certainty, by the repeated application of ordinary tar. More careful observation of industrial conditions and diseases has also found a number of illustrations of the association between tar and soot and cancer, noted originally in the classical scrotal cancer of chimney-sweeps. It is of obvious importance to discover which of the many components of the complex mixture " tar " is responsible for the malign effects. An interesting summary of the known facts is given by Dr. E. L. Kennaway (*British Medical Journal*, 1924, vol. i. p. 564). It has been found that lignite tar, gas-works tar, some forms of producer-gas tar, probably coke-oven tar, but not blast-furnace tar, are effective. Of the ordinary commercial fractions into which tar is divided, those of low boiling point appear to be innocuous, while "creosote oil," "anthracene oil," and pitch produce cancer both industrially and experimentally. The attempt to identify the actual substance has so far failed. Most of the known constituents of tar have been tried and have given wholly negative results. Dr. Kennaway suggests that the active substance is perhaps present only in very small amounts or is among the unidentified constituents. From the fact, however, that it distils over from tar over a range of 250° C. or more, it seems equally possible that the cancer-producing effect is not due to a single substance but to the combined influence of several, and that these may not be the same in all active preparations. Pending the solution of this problem, the case against the products of heated coal may be regarded as complete for practical purposes. It is encouraging to know that repeated and long-continued contact is necessary to cause any obvious effect: an occasional splash of tar is apparently quite harmless.

Plant Remains in Norway.—Plant remains of Devonian age have, during this century, been detected in two localities in Norway: in Vestland and near Röros. Now Mr. Thorolf Vogt announces in *Naturen* (Jan.-Feb., 1924) his discovery of some obscure but undoubted plant imprints in the upper part of a great basal conglomerate at Storfosen, outside the mouth of the Trondhjem Fjord. The age appears to be Lower or Middle Devonian.

Manuring and Vitamins.—The broad conclusion laid down by Eijkman and Braddon that beri-beri is due to eating too highly purified rice is not now seriously doubted. But as often happens, the general theory fails to explain all the details which intensive examination brings to light. Col. McCarrison, in a survey of the occurrence of beri-beri in India (*British Medical Journal*, 1924, vol. i. p. 414) shows that the distribution exhibits anomalies which suggest that the nutritive and vitamic values of grains are not everywhere the same. He has since (*ib.* p. 567) published experiments on pigeon beri-beri with millet grown at the Agricultural College at Coimbatore on experimental plots under different systems of manuring, and finds that there are distinct differences. Taking as a criterion the rate of loss of body weight, it seems that the grains grown without manure or without phosphates are decidedly worse than those from the plot with natural cattle manure: using the onset of paralysis as a test, natural manure is again the best. The efficacy of the grain in promoting nutrition and preventing beri-beri bears no relation to the yield per acre: no manure gave one-sixth of the yield of dung and a poor biological value; dung gave the best biological value and less than half the yield produced by complete artificials. The observations are suggestive rather than conclusive, but they show that quantity is not the final test of manurial efficiency.

Ice in the Western North Atlantic.—The March issue of the *Marine Observer* contains a short but comprehensive article on the origin and distribution of ice in the vicinity of the Newfoundland banks, together with a number of interesting charts. Field-ice, which is the name given to Arctic pack-ice, causes the greatest obstruction on Atlantic routes from late January to May. It may then be found between the south coast of Newfoundland and the forty-third parallel, and between the forty-fifth meridian and the coast of Nova Scotia. Off the east coast of Newfoundland, field-ice may be met late in summer, but farther south it quickly melts, rarely existing south of Newfoundland after the early part of May. Winter conditions in the Gulf of St. Lawrence end towards the close of April, and the pack-ice moving out of the gulf often causes a block in Cabot Strait which may last three weeks. The movements of icebergs on the Labrador banks are now fairly well understood, thanks largely to the work of the International Ice Patrol. At the Tail of the Bank the cold Labrador current, which brings the bergs, impinges on the northern edge of the Gulf Stream, and at times is split into an east and west branch. The stronger branch determines the course of the bergs, the relative strength of the branches probably depending to a great extent on the angle of impingement of the Labrador current against the Gulf Stream. After passing the Tail of the Bank, beyond the region of contact with the cold current, the Gulf Stream swings sharply to the north and north-west. The article discusses the drift of the bergs in relation to the cold current: in the warm current they melt relatively quickly.

PLATINUM IN THE TRANSVAAL.—Bulletin 101 of the South African "Industries Bulletin Series," by Dr. P. A. Wagner and Mr. T. G. Trevor, contains an interesting account of the recently discovered deposits of platinum in the Waterberg district of the Transvaal. The district in question consists mainly of felsite with some felsite tuff and a well-marked band of shale. This is traversed by one or more well-defined fissure lodes; the filling of these lodes is mainly quartz; there are also flakes of specular hæmatite together with mica and chlorite, the valuable material being the disseminated platinum, which is for the most part very finely disseminated, though in one specimen particles up to 1·3 mm. long were found. The platinum is of course not pure, but is associated, as is usually the case, with palladium and smaller quantities of iridium, the latter being sometimes entirely absent; the presence of other metals of the platinum group has not yet been definitely proved. The richness is exceedingly variable; one small picked specimen returned the enormous figure of 73 oz. to the ton, and a winze sunk to the depth of 10 ft. averaged 72 dwt. to the ton. The length over which the vein is platinum-bearing has not yet been definitely proved. The occurrence of platinum in a quartz vein is exceedingly interesting; a certain number of other similar occurrences are undoubtedly on record, but as is well known, the chief occurrences of platinum so far found have always been in connexion with altered rocks of the serpentine type. It is held to be highly probable that the new discovery can be worked at a profit, but there is at present no possibility of forecasting what the magnitude of the output is likely to be; the authors do not appear to be sanguine as to its being really large.

SOUNDING BY ACOUSTICAL METHODS.—The issue of the Journal of the Franklin Institute for March contains an account by Dr. Harvey C. Hayes, one of the research physicists of the United States Navy, of the methods which have been developed recently for sounding the harbours and rivers of the United States by means of the echo from the bottom (see also NATURE, March 29, p. 463). The first method determines the delay of arrival at a point in the bow of a vessel and at a point between the bow and stern, of the sound of the propeller reflected from the bottom. The second determines two consecutive frequencies of a sound transmitter at which the sound reflected from the bottom returns in phase with the sound emitted. The third determines the interval between two short signals such that the echo of the first arrives at the sender at the instant that the second is emitted. Depth curves obtained by these methods during the voyages of several of the ships of the United States Navy are given and they agree closely with the information by direct sounding which is available. The methods are to be used in the first instance in the harbours of America, but an exploration of the surrounding sea and ocean is ultimately to be undertaken.

REFLECTION OF X-RAYS BY CRYSTALS.—In the February number of the Journal of the American Chemical Society, Dr. G. L. Clark describes a series of precision measurements on characteristic secondary X-rays reflected by crystals from a beam of general radiation from a tungsten target. The reflection occurs both in accordance with the Bragg law and in an anomalous fashion. Rays reflected from various planes passed into a fixed ionisation chamber, the crystal was rotated and the ionisation current measured. The currents plotted against the crystal table angles gave peaks, the angles being characteristic, in the case of potassium iodide, of the planes of a cubic lattice, with a value $d_{100} = 3{\cdot}532 \times 10^{-8}$ cm. By setting the spectrometer on the angular position of a peak, rotating the crystal, and the ionisation chamber at twice the rate of the crystal, an analysis of the spectrum was made. A curve showing the characteristic K-series iodine spectrum through five orders reflected by the 100 planes of potassium iodide is given. The wave-lengths are identical with the characteristic lines in the target spectra, but the secondary rays differ materially in relative intensity from the primary rays. Iodoform, a non-polar compound, gave the iodine spectrum. The 0001 interplanar distance in the hexagonal iodoform crystal is $3{\cdot}737 \times 10^{-8}$ cm. Uranyl nitrate hexahydrate reflects secondary L-series uranium rays; the unit parallelopiped contains four molecules, is face-centred, and has the parameters in three directions at right angles of 13·01, 11·45, and $7{\cdot}93 \times 10^{-8}$ cm. The reflection of secondary characteristic X-rays is explained on the transfer of radiation momenta in quanta. No evidence of a change in wave-length due to scattering by single electrons, such as is postulated in Compton's theory, could be obtained in 16 cases tried. The existence of tertiary X-rays produced by the impact upon atoms of secondary electrons, which are in turn removed from the K- and L-rings in the radiator by the primary beam of X-rays, is announced. A tertiary ray has a frequency equal to the difference between that of a primary ray and that of the critical absorption frequency characteristic of the element of the secondary radiator.

SECONDARY STRESSES.—The new Indian bridge rules — issued last year — distinguish "primary stresses" as those which would be produced if certain broad assumptions introduced to facilitate calculation were true, whilst "a secondary stress is merely a correction to allow for the approximate nature" of the foregoing assumptions. *Engineering* for February 15 criticises this use of the term, and gives another definition—preferred by our contemporary—in which secondary stresses are classified as those arising from the redundancy of members or fastenings. Accepting this definition, there is no case recorded of any bridge catastrophe due to the existence of uncalculated secondary stresses. Alternating secondary stresses may develop cracks, but this kind of stress is rare in bridge work; such as may occur are commonly caused by change in temperature, and it is notorious that temperature stresses are much less serious in practice than would be anticipated from *a priori* considerations. The fact that any non-alternating stresses are due to redundancy implies that any local overload is transmitted to less heavily strained parts long before the metal will be stretched to the cracking point. It would appear that the whole case put forward by those who insist on the importance of secondary stresses rests almost entirely on computation. The new rules also contain a note to the effect that permissible stresses are supposed to bear some relation to the elastic limit rather than to the breaking load. Indian bridge inspectors are in future to be called on to "show clearly what 'primary' and 'secondary stresses' have been calculated and what reasons have led the inspector to assume that uncalculated 'secondary' stresses are covered by a margin between the total of the calculated secondary and primary stresses and the elastic limit." There will be a lot of tedious work in consequence of this requirement, and it is questionable whether the results will be satisfactory.

The Gas Industry.

THE extent to which the gas industry is trustee for the efficient utilisation of the nation's coal resources will be realised when it is remembered that one of the London gas companies, with a production representing about 15 per cent. of the total output of towns' gas in Great Britain, distributes annually approximately as much energy as the whole of the electrical undertakings in the country. The industry has reason to be proud of its stewardship, for the thermal efficiency of the process of carbonisation of coal as practised day in, day out, is from 70 to 80 per cent. Thermal losses are inevitable in any actual thermal process, and the operations of the gas industry are not outside the ambit of the second law of thermodynamics, high though the efficiency of the carbonising process may be. Increasing attention has in recent years been paid to potential sources of loss of thermal energy in gas-making processes in general, and the results of investigations, more especially concerned with methods of manufacture of water-gas, are embodied in some of the Reports issued by the Joint Gas Investigation Committee of the Institution of Gas Engineers and the University of Leeds, and by the Fuel Research Board.

"Gather up the fragments that remain, that nothing be lost." In the sixth Report of the Gas Investigation Committee (NATURE, August 11, 1923, p. 222) it was shown that the efficiency of production of blue water-gas as ordinarily practised in a plant without waste heat boiler is 46 per cent. The seventh Report showed that by the use of a waste heat boiler, this thermal efficiency could be increased to 53 per cent. In the tenth Report, details are given of large scale experiments carried out to ascertain whether by reducing the depth of fuel bed, as in the Dellwik-Fleischer process, the efficiency of manufacture of blue water-gas might be still further increased. During the "blow" period of operation of the plant, a regulated air blast is admitted to the fuel bed, resulting in the production of a mixture of carbon dioxide and carbon monoxide. The thermochemical equations show that during this period more than three times as much heat is liberated when the product is wholly carbon dioxide as when only carbon monoxide is produced. During the air-blow, therefore, it would appear to be desirable to obtain the maximum production of carbon dioxide. Carbon dioxide reacting with carbon yields carbon monoxide. During the "run" period, steam is passed over the incandescent fuel bed, and a mixture consisting principally of hydrogen, carbon monoxide, and carbon dioxide is produced. A consideration of the reactions occurring indicates that factors, referring to the temperature and depth of the fuel bed, operative during the two periods, influence the efficiency of the process as a whole in opposite directions. The results incorporated in the tenth Report show that the manufacture of blue water-gas by the intermittent process described can be carried out more efficiently and with a greater output per day when the carbon dioxide - carbon monoxide ratio in the blow gas is about 0·9, than when this ratio is greater than unity, and that operating in this manner, the efficiencies reported in the sixth Report might be raised to as high as 60·4 per cent.

Clause 5 of the Gas Regulation Act (1920) prescribes that, in the case of certain gas undertakings, the prescribed apparatus for testing the gas in order to safeguard the consumers' interests "shall include a calorimeter for the production of a continuous record of the calorific value of the gas." Considerable ingenuity has been shown in the construction of instruments for the specified purpose. These have embodied essentially different principles. The devices incorporated in the Simmance instrument are intended to control the flow of the heating fluid (gas) and the heated fluid (water) at respective constant rates independent of changes of temperature and pressure. In the Fairweather recording gas calorimeter, the rate of supply of gas is uncontrolled so far as temperature and pressure changes are concerned, and an ingenious device regulates the supply of water to the calorimeter in proportion to the varying supply of gas. In Prof. Boys's instrument, both gas and water are doled out positively at predetermined fixed and unalterable rates. In the calorimeter due to C. C. Thomas, air is employed as calorimetric fluid and its rate of supply to the instrument is readily maintained in strict relation to the supply of heating fluid, by means of coaxial meters having appropriate relative sizes. The Beazley calorimeter is of the "method of mixture" type.

In the eighth Report of the Gas Investigation Committee, details are given of exhaustive and searching tests to which the Fairweather recorder has been submitted, with the view of ascertaining its suitability for application in accordance with the requirements of the Act. It will be readily understood that as the accepted recorder or recorders will, in certain eventualities, be employed as the arbiter determining the fulfilment or otherwise by gas undertakings of their statutory obligations, considerable caution is necessary in the acceptance by the gas industry of any recording calorimeter as entirely trustworthy. The Report referred to indicates that the Fairweather recording calorimeter, operated under favourable conditions as to constancy of density of the gas supplied, the temperature and quality of the water supply, and receiving occasional skilled attention, should afford a record correct to within 0·5 per cent. The accuracy is decreased under variable conditions, and suggestions of constructional alterations are made in the Report whereby the instrument may be improved in this respect. The gas industry waits upon the advent of Prof. Boys's ingenious recorder in the sure hope that it will be relieved of considerable anxiety and expense in the matter of statutory testing of the calorific power of towns' gas.

The ninth Report of the Committee is devoted to the subject of aeration in gas-burners, a factor upon which the efficient operation of all atmospheric gas-burners depends, but upon which—although the Bunsen burner dates from 1855—very little trustworthy information has been hitherto available. The Report is a preliminary account of an experimental investigation of the influence of a variety of factors—the length, diameter, and outlet resistance of the burner tube, the rate, pressure, and specific gravity of the gas, the size and type of injecting jet, etc.—upon the aeration of the jet of gas.

The War period was characterised by the formation of Research Associations within certain industries. The outbreak of war was not necessary to impress upon the gas industry the prime necessity of research. Long before that its Gas Investigation Committee functioned, and the present Reports indicate that the Committee is alive to its duties and responsibilities both to the industry and the gas-using public.

J. S. G. THOMAS.

Temperature Gradient in the Earth's Crust.

Some observations on temperatures in a deep bore-hole in South Africa were described by L. J. Krige and H. Pirow in June last before the Geological Society of South Africa. The bore-hole, which had been made in search of oil, is situated on the Dubbeldevlei Farm, near Carnarvon, at an elevation of about 3250 feet above sea-level. The country is flat and underlain by nearly horizontal strata assigned to the Ecca, Dwyka, and Fish River series. These rest upon granite and gneiss at a depth of 2687 feet. The bore-hole had been carried to a depth of 5080 feet, but the lower 160 feet had become silted up. The observations on temperature ranged from the surface down to a depth of 4912 feet, and were successfully made at 26 levels. Water stands in the hole at 32 feet from the surface. The upper 1100 feet of the hole is lined with $3\frac{1}{2}$-inch casing. From 1100 feet to 3000 feet the diameter of the hole is $2\frac{15}{16}$ inches; it is then $2\frac{1}{8}$ inches to 4500 feet, and $2\frac{1}{16}$ inches from that point to the bottom.

The thermometers used were of the clinical type (that is, constricted between the bulb and the scale) and were enclosed in a brass tube 5 feet long and of $1\frac{3}{4}$ inches external diameter. They were lowered by wires, and as a result of some preliminary experiments were left at the point of observation not less than four hours in order that the true temperature should be acquired. This seems a short time, but as a fact two readings made after $4\frac{1}{4}$ hours and $11\frac{1}{2}$ hours respectively had been found to be identical.

The observations showed that the temperatures were affected by seasonal variations to a depth of 55 feet. Below this depth they ranged from 22·25° C. (72·8° F.) at 75 feet depth to 69·75° C. (157°·5 F.) at 4912 feet. They rose with depth at a maximum rate of increase of 1° C. in 60 feet in the upper part and at a minimum rate of 1° C. in 140 feet in the lower part of the hole. Plotted graphically they form a curve of considerable regularity, but becoming steeper as the rate of increase decreases with increasing depth. The curve, however, shows certain irregularities which indicate that some other cause than increasing depth is affecting the rate of increase.

On associating the curve with a geological section of the bore-hole it becomes apparent that the irregularities, and indeed the curve itself, are determined by the relative conductivity of the strata traversed. Thus the upper part of the Ecca series is composed of shales of low conductivity; in these the rate of increase is uniform at 1° C. in 60 feet. The lower part of the series includes hard shales with calcareous nodules and a sheet of dolerite 135 feet thick; in these the rate varies from 1° C. in 80 feet to 1° C. in 100 feet. Below this, in another thick bed of shale in the Dwyka series, the rate rises to 1° C. in 85 feet, but still lower in the massive Dwyka tillite and sandstone it falls to 1° C. in 125 feet. Again, in the Fish River series, it varies from 1° C. in 105 feet in sandstone and shale to 1° C. in 90 feet in some thick shales below. The lower part of the series consists of layers of shale mixed with grit and sandstone, and in these and the granite and gneiss on which they rest, the rate varied from 1° C. in 120 feet to 1° C. in 170 feet, the mean value being 1° C. in 149 feet. The highest rate in the granite and gneiss (1° C. in 120 feet) was observed in a cavernous bed, the cavities in which were assumed to cause low conductivity.

In all cases the more rapid rates of increase are associated with the lower conductivities of the rocks, the badly conducting strata, or bands in the gneiss, acting as blankets. The worst conductor, as shown in a table published in the Report of the British Association for 1881, is shale, and among the best are quartzites, sandstones, dolerite, and granite; gneiss, limestones and soft sandstones occupy an intermediate place. All of these make their presence felt in the modifications of the curve of temperatures.

The author's remark that the measurement of underground temperatures and the calculation of the geothermic gradient have not much value if the nature and dip of the rocks pierced are not studied, seems to be well justified. Obviously an occasional observation, in place of a connected series, would be more likely than not to give a wrong impression of the gradient. In my own limited experience of such work the results were so far vitiated from this cause as to be useless. They were obtained in the Talargoch Lead-mine in North Wales with all possible precautions, but showed 5° F. difference at the same depth in different parts of the workings. I concluded that "the great differences in the rate of increase of temperature in different parts of the mine may perhaps be due to the very faulty nature of the ground. In some cases the rock overlying the point of observation was principally shale, in others limestone, in part thick-bedded and massive, in part thin-bedded and shaly" ("The Geology of the Coasts adjoining Rhyl," etc., Mem. Geol. Survey, 1885, p. 58). Many of the observations made in Great Britain have been carried out in shafts or bore-holes in Coal Measures, made up of numerous alternations of sandstone, shale, and clay, sometimes horizontal but more often inclined. Presumably the temperature-curve in such cases, if sufficiently detailed, would show a number of zig-zags, and it would be a matter of chance whether or not a correct conclusion could be drawn as to the general gradient.

The paper emphasises the difficulty of obtaining sufficiently accurate data for calculating the rate of increase of temperature in the crust of the earth from observations made in the thin film which alone is accessible to us.

A. Strahan.

Radiography of Mummies.

For the first time in America, X-ray photographs of mummies were taken recently. This has been made possible by a series of experiments begun at the Field Museum of Natural History, Chicago, and the satisfactory results already obtained will doubtless open a new and important field of operations in the scientific world.

The experiments were started by X-raying a group of Peruvian mummy packs from the Necropolis of Ancon. These had been collected for the World's Columbian Exposition, held in Chicago in 1893, and since have been in the possession of the Museum. To have unwrapped these mummy packs to ascertain whether they contained objects of special interest would have meant their destruction for exhibition purposes. By means of the X-ray pictures it is possible to learn what has been buried with the body, thus determining beforehand whether or not it be advisable to unwrap the bundle.

In the mummy packs thus far examined have been found ears of corn, pottery, vessels of clay containing shells, bits of metal, gourd vessels, beads, clay figurines, cut-bone objects—or, in some instances, nothing. In addition to the range of objects found in the various bundles it is possible to gather something definite concerning the age, sex, and condition of the bony structure of the body buried therein. The nature of injuries received during the individual's life is sometimes revealed, and one can determine whether the deceased suffered from chronic rheumatism, tuberculosis of the bones, caries, arthritis of various kinds, and other diseases. In the Peruvian mummies thus far examined none of the trephining operations which were practised in Peru on its prehistoric inhabitants have been discovered.

In the Egyptian collections mummified cats, hawks, jackals, crocodiles, gazelles, and one mummy of a man of the 26th dynasty, about 600 B.C., have been radiographed with very satisfactory results.

The mummy of a man was radiographed in five sections, beginning at the head, furnishing a very clear picture of the entire skeleton. Here we may expect to find fractures, pathological conditions such as bony tumours, rickets, hydrocephalus, pyorrhœa, and caries of the teeth, all of which have been shown in the examination of unwrapped skeletal material to have been common conditions of disease among Egyptians of the most ancient times.

In the picture of a hawk, even the tail feathers are very clearly shown. The picture of the mummy of a gazelle brings out the skeleton with remarkable distinctness; that of the crocodile also shows the bones still to be in their proper relative positions. The mummy of a jackal, which was wrapped with extreme care, is shown to contain slight traces of the bony structure of that animal, while the textile material within is in a condition which indicates that it had never been disturbed since its wrappings had been placed in position. In the case of the mummy of one cat exactly the opposite state was revealed.

Further investigations are to be made upon this same class of material as well as upon vessels made of marble, alabaster, and metal. Plans are also under way to extend the work of X-raying to several other departments of the Museum. The discoveries which will result will no doubt be of importance in various fields of scientific endeavour.

University and Educational Intelligence.

CAMBRIDGE.—A Busk Studentship in aeronautics has been established in memory of Edward Teshmaker Busk, who in 1914 lost his life while flying the first stable aeroplane. The Studentship will be awarded for "research, or preparation for research in aeronautics and specially in those subjects such as stability problems, meteorological questions bearing on flight, or the investigation of gusts, treated either experimentally or mathematically, in which Edward Busk was specially interested." It is of the value of about 150*l*., tenable for one year, and may be extended for a second year. It is open to any man or woman, being a British subject and of British descent, who had not attained the age of twenty-five years on October 1, 1923. Subject to the permission of the Trustees, the Student may carry out his research either at home or abroad. Inquiries relating to the Studentship should be addressed to Prof. B. M. Jones, Engineering Laboratory, Cambridge. Applications must be returned before May 12.

DURHAM.—So far back as 1909, after the passing of the University of Durham Act, 1908, the Durham County Council considered the advisability of suggesting to the Council of the Durham Colleges a joint conference of representatives of the University and of the County Council to discuss the question of securing some co-operation and co-ordination between the two bodies. This co-operation has now been secured, and a joint board consisting of an equal number of representatives from both bodies is to administer the Department of Education. In this way, it is hoped to effect co-ordination of the whole educational system of the County of Durham from the primary school to the University, and particularly to provide a steady supply of teachers with University qualifications. For this purpose, a School of Pure Science has been established, and Dr. Irvine Masson, reader in inorganic chemistry at University College, London, has been appointed professor of chemistry and director of the Science Department. The facilities afforded by the City of Durham in its provision of residential Colleges, the recent affiliation of Bede College and St. Hild's College to the University, and the establishment of the Neville's Cross College, give ground for confidence that the provision of further branches of study in addition to the ancient and flourishing School of Arts in the University will contribute both to the prosperity of the University and the higher education of the County at large. It is hoped that the first science students will be admitted in October next. The plans and specifications of the new buildings have been prepared under the personal supervision of Dr. W. N. Haworth, professor of organic chemistry in Armstrong College, Newcastle-upon-Tyne, and they include provision for the teaching and demonstration of chemistry, physics, geology, and botany.

LONDON.—Among the public lectures for this term which have been arranged by University College are the following: "Some Questions concerning the Influence of Tropical Climate on Man," by Prof. C. Eijkman, of the University of Utrecht, on May 2, at 5 o'clock; "Positive and Negative Valences," by Prof. W. A. Noyes, of the University of Illinois, on May 5; "Kant's Theory of Beauty and Sublimity," by Prof. G. Dawes Hicks, on May 12, 19, and 26; "Sir Thomas Browne, author of the *Religio Medici*: His Skull and Portraits," by Miss M. Tildesley, on May 20; "On the Nature of Science," by Profs. A. N. Whitehead and T. Percy Nunn, on May 22 and 29; "Objective and Subjective Physics," by Prof. A. Haas, of the University of Vienna, on May 30, at 5.15; "L'archéologie de la Syrie," by M. F. Cumont, on June 12, 13, and 16. Public introductory lectures to courses include the following: "The Psychology of the Learning Process," by Mr. S. Philpott, on May 1; and "Recent Discoveries in Egypt," by Sir Flinders Petrie, on May 15. Prof. R. A. Millikan, of the California Institute of Technology, Pasadena, U.S.A., is to deliver three public lectures on physics on June 13, 17, and 19. Except where otherwise stated, the lecture-hour is 5.30.

A course of three public lectures on "The Pre-Cambrian, with special Reference to that of Ontario," will be given at the Imperial College, Royal School of Mines, by Dr. W. G. Miller, Provincial Geologist of Ontario, at 5.15 on Tuesdays, May 13, 20, and 27.

THE Secretary of the Smithsonian Institution at Washington announces that the time-limit for receiving applications for the Walter Rathbone Bacon Travelling Scholarship has been extended to June 1. This scholarship, founded through a bequest from Mrs. Virginia Purdy Bacon, of New York, is for the "study of the fauna of countries other than the United States," the amount available being about 2400 dollars per year. Applications for the scholarship, addressed to the Secretary of the Smithsonian Institution, should contain a detailed plan for the proposed study, including a statement as to the faunal problems involved. The scholarship will be awarded for a term of two years, and may be extended. All collections, etc., made by the holder of the scholarship become the property of the Smithsonian Institution.

THE Carnegie Foundation for the Advancement of Teaching has recently issued its eighteenth annual report—a document of noteworthy importance not only in America but in all civilised countries. The problem with which the Foundation has primarily concerned itself is that of retiring allowances for college teachers, and the report claims that a scientific and successful solution has been reached in the Teachers Insurance and Annuity Association of America—" the greatest contribution that has been made toward the protection of the teacher upon conditions that secure life, safety, and independence." Year by year, the Foundation has recorded in its reports descriptions of all pension systems in all parts of the world having any relation to the question of teachers' pensions, and has thus accumulated the most complete literature bearing on the subject to be found anywhere. In addition to dealing with the problem of retiring allowances, the Foundation has, from time to time, caused exhaustive studies to be made of a number of other subjects which have appeared to it to stand in need of investigation, such as medical education, legal education, and engineering education. These studies, together with others concerned with underlying fundamental questions relating to good teaching, the content of the curriculum, and the cost of public education, have been published in sixteen bulletins. The annual report contains interesting articles on legal and dental education, the abuse of intercollegiate athletics, the influence of alumni upon their colleges, and other topics.

INTER-UNIVERSITY connexions have steadily grown in number and importance since the Universities' Congress of 1912 decreed the establishment of a Universities' Bureau of the British Empire. Since the War, this movement has been accelerated, and the efforts of university administrative authorities to co-operate in the pursuit of common aims have been followed by like attempts by associations of university teachers, university graduates, and university students. Two of these bodies have recently produced inter-university journals—the *University Bulletin* of the Association of University Teachers and the *National Union News* of the National Union of Students of the Universities and University Colleges of England and Wales. The March number of the *University Bulletin* contains an address by the newly-elected president of the association—Prof. F. C. Lea, of the University of Birmingham. After discussing the financial needs of universities Prof. Lea observes that from inquiries among members of Parliament it appears that the country would readily sanction the grant of an additional 500,000*l.* per annum to universities. Prof. Alexander Mair, of the University of Liverpool, contributes an article on advanced study and research in which he directs attention to the advantages of the establishment of funds or regular annual appropriations for the assistance of research, and commends as worthy of imitation the action of Birmingham in setting up a Joint Standing Committee for Research, the duties of which include advising the Council of the amount required to enable the research work of the session to be carried out and the consideration of proposals for facilitating research, as by grants in aid of publication, leave of absence or exemption from teaching duties, and reporting thereon to Council. He states that the branches of the association are solidly against the research professorship idea.

Early Science at the Royal Society.

April 27, 1664. A letter of Col. Long was read, wherein he proposed to send up his boxes with insects and other curiosities of nature, to be put among the rest of the things, which were preparing for the King's reception; upon which it was ordered that the secretary should thank Col. Long for his respects to the Council, and acquaint him that he should have timely notice of the day.

April 28, 1670. It was ordered, that the operator should immediately bespeak a glass-tube as large as could be made, and eight feet long at least, for making experiments of the descent of bodies in water.

1686. Dr. Vincent presented to the Society a manuscript treatise, intitled, *Philosophiæ Naturalis principia mathematica*, and dedicated to the Society by Mr. Isaac Newton, wherein he gives a mathematical demonstration of the Copernican hypothesis as proposed by Kepler, and makes out all the phaenomena of the celestial motions by the only supposition of a gravitation towards the center of the sun decreasing as the squares of the distances therefrom reciprocally. . . . It was ordered that a letter of thanks be written to Mr. Newton; and that the printing of his book be referred to the consideration of the council; and that in the meantime the book be put into the hands of Mr. Halley to make a report thereof to the council.

April 29, 1663. Dr. Wren showed his model of the theatre to be built at Oxford for the University acts, and upon occasion for plays; and was desired to give in writing a scheme and description of the whole frame of it, to remain as a memorial among the archives of the Society.

1669. It was moved, that when any of the beasts or birds of the King died, Mr. May might be spoken to by Sir Robert Moray to send them to the society.

April 30, 1662. Sir Robert Moray read his account of the satellites of Jupiter on Friday the 25th of this month. . . . The operator was ordered to provide against the next meeting two birds, one a chicken, and another bird, and a live mouse or two.

1674. Mr. Oldenburg read a copy of a letter written to Mr. Hevelius by Dr. Wasmuth, importing that the said Dr. rejecting all the three famous hypotheses of astronomy, had pitched upon another, of his own invention. There being many other very magnificent promises in this letter, the sense of the members present seemed to be, that he had promised too much to answer expectations.

1684. Mr. Musgrave gave an account of the effects of the late hard frost in the garden of the university of Oxford. It being said therein that trees of active juices had suffered most by the frost, Dr. Lister answered, that the maple and sycamore will bleed all winter, and yet they had not suffered.

May 1, 1679. Mr. Hooke produced his new way of ordering pieces of elm for the making of an hygroscope; upon which it was desired, that there should be one of this kind prepared to stand in the meeting-room of the Society.

May 2, 1667. Mr. Hooke having proposed the experiment of measuring the circumference of the Earth for the Monday morning following in St. James's Park at the canal; it was ordered, that the apparatus for it, viz., a telescope of 12 or 15 feet and some stakes, should be made ready against that time.

1678. It was suggested by Mr. Hooke, that probably the healing [effect] of plaisters might be from nothing else than the keeping of the air from preying upon the tender wounded part, and from keeping in the moisture to keep it tender and supple.

Societies and Academies.

London.

Association of Economic Biologists (Leeds Meetings), February 22 and 23.—G. T. **Spinks**: Propagation of fruit trees on their own roots. Many variations have been tried in the manner of taking cuttings, in the medium in which they were placed and in the conditions to which they were exposed, but very few rooted cuttings have been obtained, though many of them formed a good callus. Other methods, such as layering and the use of "nurse-roots," have been found to be more successful. Observations on root formation on apple trees and black-currant bushes suggest that stores of organic food reserves in the plant, aeration, and an adequate moisture supply are important factors in determining root formation. A physiological explanation of the cause of free or difficult rooting is required.—R. C. **Knight**: Experiments on the rooting of hardwood cuttings. Hardwood cuttings of plums, apples, and cherries were planted in the open in different soils representing different degrees of soil moisture and aeration. The results of four years' trials show that in plums the process of callus formation was favoured in heavier soils where the water content was higher, whilst the later process of root formation was favoured in lighter soils where aeration was more efficient. In a year of heavy autumn rainfall the cuttings callused almost as well in sand as in a clay soil, but in a dry autumn callus formation was five times as great in the clay soil as in sand. Root formation in the heavy soil was best in a dry season. Apples and cherries gave indications of similar responses. In a light loam, callus formation was greater in a wet than in a dry situation.—W. **Robinson**: Vegetative buds on leaves of *Cardamine pratensis*.—J. H. **Priestley**: Vegetative propagation of flowering plants. Two points of importance appear to be (1) the distribution of actively growing (meristematic) tissues upon the piece of plant selected for propagation, and (2) the supply of food to this meristem. Considered in terms of these factors, it is possible to draw up series of plants in which propagation may be expected upon structural grounds to occur with decreasing facility, but no adequate explanation has been given, for example, of the difficulty of rooting apple scions or obtaining buds from wallflower roots. In Dicotyledons where such meristematic tissues are present, buds come from the cork cambium and roots from the vascular cambium.

Royal Microscopical Society (Industrial Applications Section), March 26.—Dr. Stephen Miall in the chair. —G. O. **Searle**: Methods of mass-production in sectioning flax stems. In carrying out a genetic investigation of certain fibre characters of the flax plant, it was found necessary to devise a method by which transverse sections of up to 3000 flax stems could be cut and mounted by one person within a limited available period of about four months each year. The method finally devised consists essentially of making kite tails of cotton each with small pieces from forty stems; in this way 1000 stems could be dehydrated and embedded in celloidin at one time without mixing. After microtoming, the sections, six from each stem, three of which were later discarded, were placed in small silk-ended tubes, and forty of these tubes were placed in a larger long glass tube into which solutions could be poured as required; in this manner the sections were uniformly double-stained and dehydrated ready for mounting. A careful record of time and materials was kept, and it was found that 2000 stems could be dealt with and three sections from each stained and mounted at an expenditure in time amounting for one person to six hours per day for 84 days, and an expenditure of materials equalling 2½d. per stem, half of which was the cost of slides and cover glasses.

Linnean Society, April 3.—C. **Turner**: Investigations on Desmids (contd.). In some Desmids, an enclosed cavity is formed between the organisms during conjugation. In its early stages it consists of a definite band of protoplasm, which soon increases and becomes cask-like in character, with the two Desmids attached, one at each end. They discharge their contents into the cavity, which is subsequently closed by a thin membrane; the integument becomes the exospore of the zygote. The abnormal conditions of 1921 caused abnormal methods of perennation, and aplanospores occurred in *Staurastrum punctulatum* Breb. and *Cosmarium Meneghinii* Breb., in which they have not been previously mentioned.—H. S. **Holden**: On the occurrence of cavity parenchyma and tyloses in ferns. Cavity parenchyma, though generally confined to the petiolar protoxylem areas in the Filicales, frequently occurs in similar areas in the rhizomes of *Pteridium aquilinum* and *Matonia pectinata*. True tyloses, resulting in the occlusion of the metaxylem, occur in wounded roots of *Marattia fraxinea*. The growths occluding the metaxylem elements in the fossil fern *Ankyropteris corrugata* appear to be true tyloses.—H. S. **Holden** and Miss A. Evelyn **Chesters**: On the seedling anatomy of some species of Lupinus. The seedlings of the seventeen species examined are uniformly diarch in plan. They may, from an anatomical point of view, be arranged in a series showing a progressively wider separation of the two metaxylem groups from the central protoxylem and a lowering of the level at which typical root structure is attained. The initial stages in the separation of the xylem groups are brought about by the replacement of the tangentially developed elements by parenchyma. The final term in the series may represent one of the steps by which diagonal tetrarchy has been attained.—W. O. **Howarth**: The occurrence and distribution of *Festuca ovina* L., sensu ampliss. Hack. in Britain. Vivipary is common in all the five forms described except perhaps *F. glauca*. The viviparous *F. supina* is certainly a distinct race, true to this character under cultivation. There may be another pure race as suggested by Jenkin (Aberystwyth), but viviparous states of the other species can be recognised, and are probably brought about by conditions affecting the growth of the panicle during the early stages of its development, such as extreme humidity associated possibly with lower temperatures or drought.

Paris.

Academy of Sciences, March 31.—M. Guillaume Bigourdan in the chair.—A. **Lacroix**: New observations on the nephelene syenites of the Los islands (Guinea). A detailed description of the minerals present in these syenites, together with results of complete chemical analyses of seven of them.—H. **Andoyer**: The analytical theory of the movement of the moon.—Daniel **Berthelot**: Remarks on a note of M. Bochet relating to the law of corresponding states.—G. **Ferrié**, R. **Jouast**, and R. **Mesny**: The amplification of the current of photo-electric cells by means of lamps with several electrodes. In a previous communication two methods of utilising valves for the amplification of photo-electric currents have been described, one of which required the use of specially selected lamps. The modified method described in the present note is free from this objection, and allows ordinary commercial valves to be used. The application of the apparatus to stellar photometry is indicated, and measurements given for Capella, β Auriga, and θ Origa.—André **Blondel**: Complementary remarks on the revolving vibrations and critical resonance of the axles of internal combustion motors with several cranks with or without receiving apparatus. — G. **Friedel** and G. **Ribaud**: A transformation of the diamond. Although the diamond crystallises in the cubical system, most specimens show double refraction irregularly distributed. This cannot be due to strains set up by unequal cooling or to external mechanical action. A polymorphic transformation accompanied by a change of volume is suggested as a probable hypothesis. Experiments are described giving some support to this view, a transformation taking place at 1885° C., causing fracture of the crystal and change in the double refraction. Above 1885° C. no diamond can exist, as it is transformed into graphite.—L. **Cuénot**, R. **Lienhart**, and P. **Vernier**: The transmissibility of an acquired somatic character. A discussion of the work of Guyer and Smith on the inheritance of eye defects induced in rabbits, and a description of some experiments bearing on the same problem.—Charles **Nicolle**, P. **Durand**, and E. **Conseil**: The multiplicity of the races of Weeks's bacillus. The frequent occurrence of this organism on the human conjunctiva without acute conjunctivitis.—A. **Vakselj**: Linear substitutions.—E. **Vessiot**: A new theory of the problems of integration.—J. **Haag**: A question of probabilities.—Charles **Platrier**: The torsion resonances of transmission axles.—M. **Lémeray**: The local validity of a theorem of the old dynamics. Different meaning of the word velocity in the theory of relativity.—A. **Leduc**: The specific heats of gases and the velocity of sound. The particular case of air. The specific heats of air between 15° and 100° C. as calculated from the velocity of sound are $C_p = 0{\cdot}2403$, $C_v = 0{\cdot}1713$. A correction term is introduced in the expressions for the deviation of air from a perfect gas.—P. **Lebeau** and M. **Picon**: An arrangement permitting electrical heating to a high temperature in a vacuum. The furnace, of which details of construction and mode of working are given, gives a temperature up to 2400° C. in a vacuum, and permits the determination of the temperature to within 25° C.—L. **Vegard**: The emission of light by solid nitrogen and the origin of the spectrum of the aurora. Reproductions are given of the spectra obtained by the bombardment of solid nitrogen by the cathode rays, the nitrogen being deposited on a copper surface cooled by liquid hydrogen. The spectrum obtained under these conditions is the typical aurora spectrum, and this confirms the author's hypothesis concerning the constitution of the upper atmosphere and the origin of the spectra of the polar aurora.—H. **Chipart**: The theories of light waves and Carnot's principle.—Paul **Bary**: The polymerisation of the cellulose molecule.—A. **Bigot**: Apparatus for the treatment of town refuse. In this apparatus the refuse is first dried and sterilised at temperatures up to 200° C., then hand-picked, and burnt. The ashes, after passing through a magnetic separator, may be utilised as agglomerate for cement or for other useful purposes.—P. **Mondain-Monval**: The law of solubility of salts.—M. **Audibert**: The explosive decomposition of nitroglycerol.—MM. **Volmar** and **Stahl**: The influence of agitation on the formation of precipitates. The contamination of barium sulphate with nitrate, or of strontium sulphate with magnesium salts, can be prevented by a rapid mechanical agitation of the liquid during precipitation.—F. **Bourion** and E. **Rouyer**: The ebullioscopic study of the formation of double salts between mercury cyanide and the haloid salts of the alkalies and alkaline earths. — G. **Austerweil**: The eutectics of camphene with other terpenes. — C. **Dosios**: A particular case of filtration.—B. **Bogitch**: The formation of *loups* in metallurgical furnaces.—R. **Locquin** and W. **Sung**: Pennone or 2.2.3.3.tetramethyl-4-pentanone. — L. **Bert**: The action of mixed dialkyl sulphates on mixed organo-magnesium compounds.—Marcel **Godchot** and Pierre **Bedos**: The preparation of stereo-isomers in the disubstituted cyclohexanol series.—E. E. **Blaise** and A. **Cornillot**: A new synthesis of α-n-butylpyrrolidine.—Emile **André**: The identity of phocenic and valerianic acids. Phocenic acid was isolated by Chevreul in 1817 from the fat of the dolphin; valerianic acid was obtained in 1819 by Pentz from valerian root. These two acids are now shown to be identical.—Octave **Bailly** and Jacques **Gaume**: An extension of the work of King and Pyman on the products of interaction of α-chlorhydrin and sodium phosphate.—J. F. **Durand**: The volumetric estimation of carbon. The oxidising agent employed is permanganic anhydride, prepared by titurating an excess of potassium permanganate with strong sulphuric acid, and the oxidations are carried out at the ordinary temperature. The method is not generally applicable, but examples are given showing that correct results are obtained for numerous organic substances.—Ph. **Négris**: The improbability of a drift of continents. An adverse criticism of A. Wegener's theory of the drift of continents.—M. E. **Denæyer** and **Carrier**: The principal geological and lithological results of the Ouadaï-Darfour delimitation expedition.—Ladislas **Gorczynski**: A direct reading or self-recording thermo-electric pyroheliometer.—L. **Eblé**: Magnetic measurements in the Paris basin.—A. **Goris**: The chemical composition of chlandestine. — Lucien **Daniel**: The winter migration of inulin from the aerial tubercles in the Jerusalem artichoke.—André **Dauphiné**: First results of the experimental separation of dicotyledonous embryos into two phyllorhiza.—A. C. **Guillaume**: Researches on the functions of the blood capillaries.—Pierre **Girard** and Marcel **Platard**: A new mechanism of the oxidation-reduction process related to the biochemical process.—A. Ch. **Hollande**: Coloration of the granulations called "oxydasic" of the cells obtained by synthesis of indophenol and of oxybenzidine.—Paul **Mathias**: The evolutive cycle of a trematode of the family of Psilostomidæ (*Psilotrema spiculigerum*).—A. **Ponselle**: Culture of the pathogenic trypanosomes. The formula of a culture medium is given, gelatine-peptone with sodium chloride and carbonate, on which four pathogenic trypanosomes grow readily.—F. **Bordas**: A metallic thermocautery with variable temperature. A description of an instrument for applying very low temperatures locally.—Edmond **Chaumier**: The subcutaneous vaccination of animals with the view of obtaining pure vaccine.—Léon **Blum**: The perlingual administration of insulin.

Washington, D.C.

National Academy of Sciences (Proc. Vol. 10, No. 2, February).—G. E. M. **Jauncey**: The scattering of X-rays and Bragg's Law. It has been found experimentally that wave-lengths calculated from second-order reflections are slightly less than those obtained from first-order reflections. This is not accounted for by Compton's theory of change of wave-length on scattering; while Darwin's theory of a refractive index for X-rays in solids offers an explanation.—B. **Davis** and R. **von Nardroff**: Refraction of X-rays in pyrites. The rays are bent by refraction as they pass through the surface of a crystal. Reflections from a natural (100) face of a crystal of pyrites were compared with those obtained from a crystal surface ground so that it made a small angle with the reflecting planes. The bending of the rays increases with increase of this angle, and the experimental results are in accord with Lorentz's dispersion formula for light. Angles on the spectrometer are measured by an optical device to an accuracy of 1″.—R. S. **Detwiler**: The effects of replacing the cephalic end of the embryonic spinal cord by an extraneous medulla in Amblystoma. In the few animals which survived, there was unusual proliferation of the cells in the segments caudal to the transplanted medulla.—R. G. **Harrison**: Some unexpected results of the heteroplastic transplantation of limbs. Though eventually the fore-limb of the tiger salamander is larger than that of the spotted salamander, that of the latter appears relatively much earlier during development. Exchanging the limb buds of the two species does not change the relative rate of development greatly, but a "tiger" bud grafted on to a spotted salamander gives rise eventually to a limb much larger than that of a normal specimen of either species. Two factors, growth potential (in the graft) and a regulator (an internal secretion of the host), appear to be concerned.—E. V. **Huntington**: Sets of completely independent postulates for cyclic order.—E. B. **Wilson**: The development of a frequency function and some comments on curve fitting. A simple curve, fitting observations roughly, may suggest a working hypothesis leading to the discovery of a natural law; a complicated but good fit may be in its detail obscure.

Official Publications Received.

Agricultural Research Institute, Pusa. Bulletin No. 146: The Prevention of Nuisances caused by the Parboiling of Paddy. By J. Charlton. Pp. 38. 5 annas. Bulletin No. 148: The Relative Responsibility of Physical Heat and Micro-organisms for the Hot Weather Rotting of Potatoes in Western India. By Prof. S. L. Ajrekar and J. D. Ranadive. Pp. 18+3 plates. 5 annas. Bulletin No. 149: A Study of the Factors Operative in the Value of Green Manure. By Dr. P. E. Lander, B. H. Wilsdon, and M. Mukand Lal. Pp. 23. 5 annas. Bulletin No. 150: The Improvement of Fodder and Forage in India. (Papers read before a Joint Meeting of the Sections of Agriculture and Botany, Indian Science Congress, 1923.) Edited by Gabrielle L. C. Howard. Pp. vi+58. 6 annas. Bulletin No. 151: A Method for the Accurate Determination of Carbonic Acid present as Carbonate in Soils. By Phani Bhusan Sanyal. Pp. 8. 2 annas. (Calcutta: Government Printing Office.)

Department of Agriculture, Straits Settlements and Federated Malay States. Bulletin No. 34: The Two-coloured Coconut Leaf Beetle (*Plesispa reichei*, Chap.). By G. H. Corbett. Pp. 20+3 plates. (Kuala Lumpur.) 50 cents.

The Mineral Deposits of Burma. By Dr. G. de P. Cotter. Pp. iii+53. (Rangoon: Government Printing Office.)

The Institution of Civil Engineers. Engineering Abstracts prepared from the Current Periodical Literature of Engineering and Applied Science, published outside the United Kingdom. Supplement to the Minutes of Proceedings of the Institution. New Series, No. 19, April. Edited by W. F. Spear. Pp. 180. (London: Gt. George Street, S.W.1.)

Proceedings of the Royal Society of Edinburgh. Vol. 44, Part 1, No. 5: A Geometrical Interpretation of the Complete System of the Double Binary (2, 2) Form. By Prof. H. W. Turnbull. Pp. 23-50. 2*s.* 6*d.* Vol. 44, Part 1, No. 6: Note on the *m*-line Determinants whose Elements are $(m-1)$-line Minors of an m-by-$(m+k)$ Array. By Sir Thomas Muir. Pp. 51-55. 9*d.* Vol. 44, Part 1, No. 7: Studies in Clocks and Time-keeping. No. 3: Comparative Rates of Certain Clocks. By Prof. R. A. Sampson. Pp. 56-76. 1*s.* 9*d.* (Edinburgh: R. Grant and Son; London: Williams and Norgate.)

Proceedings of the Royal Irish Academy. Vol. 36, Section B, No. 6: Pasteur Centenary Celebration. Addresses by Dr. William Robert Fearon, Prof. Sidney Young, Prof. Roger Chauvire. Pp. 49-64. 1*s.* Vol. 36, Section B, No. 7: Notes on the Human Ovary, with Special Reference to a Corpus Luteum of Ovulation. By Prof. J. Brontë Gatenby. Pp. 65-90+3 plates. 2*s.* (Dublin: Hodges, Figgis and Co.; London: Williams and Norgate.)

Diary of Societies and Public Lectures.

MONDAY, April 28.

Faraday Society (in conjunction with the Institute of Metals) (at Institution of Mechanical Engineers), at 3.—Discussion on Fluxes and Slags in Metal Melting and Working.—Prof. C. H. Desch: General Introduction.—A. Portevin: Oxidising Fluxes in the Melting of Non-Ferrous Metals.—R. Genders and A. L. Haughton: The Use of Fluxes in Brass Melting.—G. Rigg: Slags from Lead, Copper, and other Blast Furnaces.—Dr. A. Scott: Slags in Relation to Copper and Brass.—J. Phelps: Slags produced in Melting Silver Alloys.—B. Bogitch: Sulphurising and Desulphurising of Metals by Basic Slags and Fluxes.—At 5.—Prof. B. P. Haigh: Slag Inclusions in Relation to Fatigue.—H. Ogden: Fluxing Problems in Welding or Mild Steel with the Metallic Arc.—C. Coulson-Smith: Fluxes and Slags in Oxy-Acetylene Welding.—W. Spraragen: Fluxes and Slags in Welding.—Dr. W. Rosenhain and L. Archbutt: The Use of Fluxes in the Melting of Aluminium and its Alloys.—A. G. Lobley: Non-Metallic Inclusions in Metals, with Special Reference to Aluminium.—Dr. G. T. Bailey: Fluxes used in the Tin Plate Industry.—T. B. Crow: Fluxes in Soft Soldering.

Victoria Institute (at Central Buildings, Westminster), at 4.30.—Dr. A. T. Schofield: The Making of Men.

Royal College of Surgeons of England, at 5.—V. E. Negus: New Points in the Mechanism of the Larynx.

Aristotelian Society (at University of London Club), at 8.—A. E. Heath: The Functional Aspect of Scientific Conceptions.

Illuminating Engineering Society (at Royal Society of Arts), at 8.—E. L. Oughton (Gas Lighting) and P. J. Waldram (Daylight Illumination) and others: Discussion on Some Problems in the Lighting of Textile Mills.

Royal Society of Medicine (Odontology Section), at 8.—J. H. Badcock: The Prevalence of Supernumerary and Supplemental Teeth among the Natives of India (with examples contributed by C. H. Badcock of Madras).—J. Howard Mummery: The Nerve Distribution to the Dentine.

TUESDAY, April 29.

Zoological Society of London, at 4.—Anniversary Meeting.

Royal Institution of Great Britain, at 5.15.—Prof. J. Barcroft: The Effect of Altitude on Man (1): Muscular Work.

Institution of Civil Engineers, at 6.—H. N. Allott and S. L. Pearce: The Barton Power-Station of the Manchester Corporation, and the Transmission System in connexion therewith.—W. Burnside: Dalmarnock Electricity Works.

Institution of Automobile Engineers (Informal Meeting) (at Royal Society of Arts), at 6.30.—Discussion on The Respective Merits of the Coil and Magneto Systems of Ignition.

Institute of Marine Engineers, Inc., at 6.30.—L. Miller: The Electric Motor Drive for Auxiliary Machinery on board Ship.

Royal Photographic Society of Great Britain, at 7.—C. Friese-Green: The New Friese-Green Colour Film.

WEDNESDAY, April 30.

Royal College of Surgeons of England, at 5.—Prof. W. E. Gallie: The Transplantation of the Fibrous Tissues in the Repair of Anatomical Defects.

Royal Institution of Great Britain, at 5.15.—F. Balfour Browne: Social Life among Insects (1).

Institution of Civil Engineers, at 6.—Annual General Meeting of the Association of London Students.

Radio Society of Great Britain (at Institution of Electrical Engineers), at 6.—Capt. P. P. Eckersley: Faithful Reproduction by Broadcast (Lecture).

Royal Society of Arts, at 8.—Brig.-Gen. Sir Henry Maybury: The London Dock District and its Roads.

British Psychological Society (Medical Section) (at Royal Society of Medicine), at 8.30.—Dr. E. Glover: The Significance of the Mouth in Psycho-Analysis.

THURSDAY, May 1.

Linnean Society of London, at 5.—E. Clement: Germination of Orchid Seeds without Fungal Aid.—J. Gray: Some Problems of Experimental Cytology.

Royal Institution of Great Britain, at 5.—Annual Meeting.

Chemical Society, at 8.—H. W. Carnelley and P. K. Dutt: Iminodihydro-1:2:3-triazole. Part II. Intra-annular Migration of the Dyad Type and Intra-nuclear Tautomerism without Migration.

Royal Society of Medicine (Obstetrics and Gynæcology Section), at 8.—Annual General Meeting.

FRIDAY, May 2.

Royal Society of Arts (Indian Section), at 4.30.—Prof. Jocelyn F. Thorpe: Chemical Research in India.

Royal College of Surgeons of England, at 5.—H. E. Griffiths: Further Relationships of Diseases of the Gall Bladder to the Secretory Functions of the Stomach and Pancreas.

Junior Institution of Engineers, at 7.30.—F. H. Taylor: Electric Lighting in Churches.

Philological Society (at University College), Anniversary Meeting, at 8.—Presidential Address.

Royal Society of Medicine (Anæsthetics Section), at 8.30.—Annual General Meeting.

Royal Institution of Great Britain, at 9.—Sir Alexander Kennedy: Petra.

SATURDAY, May 3.

Royal Institution of Great Britain, at 3.—Dr. F. A. E. Crew: Heredity and Sex.

PUBLIC LECTURES.

WEDNESDAY, April 30.

King's College, at 5.30.—Sir William Beveridge: Economic Problems of the Empire.

THURSDAY, May 1.

University College, at 5.30.—S. Philpott: The Psychology of the Learning Processes.

FRIDAY, May 2.

University College, at 5.—Prof. C. Eijkman: The Influence of Tropical Climate on Man (in English).