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The Supply of Petroleum Products.

MR. SYDNEY BROOKS contributes to the *Fortnightly Review* for September 1 an article entitled "A British Oil Victory," from which the reader might at first infer the discovery of a large British oilfield or at least a sudden remarkable flow from the Hardstoft well in Derbyshire. Nothing quite so startling has happened, however; Mr. Brooks's "victory" is of a far less sensational character, being, in fact, the opening of the Anglo-Persian Oil Company's refinery at Llandarcy, Swansea. The author regards this event as the *pièce de résistance* of a series of British achievements in the "international war of industry," and mentions in the same breath the opening of the Manchester Ship Canal Oil-Dock, the discovery of oil in Papua, and the securing by a British Company of the oil rights of Macedonia.

It seems a pity to have to disillusion Mr. Brooks and his readers, but while one admires his natural pride in British commercial successes, and also the patriotic zeal with which he writes, there is in his article an optimism apparently born of an inadequate knowledge of the facts and a clouded sense of proportion. The Llandarcy refinery is admittedly a sound industrial proposition for this country, but one can scarcely recognise yet in its existence a really serious competitor with the Shell or Anglo-American Oil Companies' interests, as Mr. Brooks suggests. Even if the Anglo-Persian Oil Company agreed to distribute their petroleum products solely in the British Isles, this would only represent a relatively small percentage of the total annual consumption of such commodities in this country. The bulk of imports of petroleum products come from the United States and Mexico; they are controlled by the Dutch and American organisations referred to and together constitute more than twenty-five times the amount of such products obtained from Persia, based on recent statistics of production and importation.

There is always the possibility—indeed, the probability—that the Anglo-Persian Oil Company's interests will expand considerably in the next few years, but a refinery, however large and well-equipped, is dependent on an abundant supply of crude oil, and this must come to us from overseas. So long as the United States and Mexico together produce more than 85 per cent of the world's supply of crude petroleum, so long shall we be dependent on those countries and their representatives for the bulk of our supplies of petroleum products.

The construction of the Llandarcy refinery is indeed an industrial event of no mean importance, but at least let us preserve a clear perspective in the matter. The

Manchester Ship Canal Oil-Dock should be hailed rather as an engineering feat than an "oil victory"; without plenty of imported oil the dock ceases to exist as such. The strike of oil in Papua is not surprising; both in British and former German territory oil occurrences have long been known; geological surveys have been made and the oil sampled, but the technical difficulties, an appalling climate and the native labour troubles involved, have retarded development, even if oil exists in commercial quantity—yet a moot point. Then the Macedonian concessions are, geologically speaking, even more doubtful than Papua as regards oil potentialities: their securance may have been a political or commercial *coup*, but as an incident in the "British Oil Victory," it was neither heroic nor decisive.

We suggest to Mr. Brooks that in the general appreciation of the above facts lies the reason of apparent public indifference to the erection of the Llandarcy refinery; the matter was neither ignored nor its significance missed, as he complains; it is simply that to the average man this and kindred propositions appeal as ordinary extensions to business, and where oil is concerned especially, judgment by results rather than hasty optimism at the beginning is the safer policy.

H. B. M.

The Ways of Insects.

The Psychic Life of Insects. By Prof. E. L. Bouvier. Translated by Dr. L. O. Howard. Pp. xvii+377. (London: T. Fisher Unwin, Ltd., 1922.) 8*s.* 6*d.* net.

THIS is, we think, the most reasonable book that has been written on insect behaviour as a whole. It is scholarly and critical; it avoids extremes; and it leaves open questions open. There is, as every one recognises, an inclined plane of insect behaviour. On the lowest level there are tropistic activities (the translator's term "tropic" will not do), when the insect makes towards or away from the light, against the stream or the wind, towards or away from an odour, and so on. In everyday life these tropisms count for much. They are obligatory constitutional automatisms; they are induced by asymmetry of stimulus which provokes asymmetry of muscular activity; and this automatically restores physiological equilibrium. Interesting situations arise when one tropism (*e.g.* in relation to light) influences or counteracts another (*e.g.* in relation to gravity); and it is also noteworthy that a tropism may change its character with the age or physiological state of the organism.

Then we have to recognise internal rhythms which are enregistered in the insect's constitution and imply a certain organic memory. Very suggestive is Roubaud's case of the African "house-worms" (maggots of *Auchmeromyia luteola*) which burrow in the earthen floor of the hut during the day, but come up at night to gorge themselves on the blood of the prostrate sleepers. For Roubaud has proved that these larvæ experimentally treated can be induced to remain awake during the day. The rhythm is constitutional, but its punctuation is environmental.

Bouvier passes to the phenomena of "differential sensitiveness"—a term which never strikes us as very luminous. When a bed-bug, which naturally seeks darkness, is suddenly illumined, its typical behaviour is to turn through 180 degrees and proceed in the opposite direction. Insects avoid situations or postures which are contradictory to the exercise of their normal tropisms; but their behaviour is automatic, not voluntary. Moreover, the reversal of the movement in relation to a particular stimulus, say light, may be induced by a sudden change in some other stimulation, *e.g.* by a gust of wind or a warm breath. The familiar phenomena of "catalepsy" or "feigning death" *in insects* are regarded as exaggerations of "differential sensitiveness," and the author is very sceptical as to utilitarian interpretations.

So far there is no appreciable psychical note. That is not struck till we find the insect selecting one reaction rather than another, profiting by experience in a simple way, and showing individual as contrasted with organic memory. Some very interesting examples are given of an individual change of habit in novel circumstances. The intelligent adjustment of habits has played an important part in the evolution of instinctive behaviour, for insects have "the power very quickly to transform acts which are intelligent at first into automatic acts."

Bouvier's position in regard to instinctive behaviour is eclectic. There is no special faculty of "instinct," and the various forms of instinctive behaviour are not all on the same level nor of the same origin; some may have arisen as germinal mutations (which will be afterwards tested in everyday life), while others may have arisen in the course of intelligent apprenticeship. "In an intelligent way, new habits are established, which by heredity are added to the patrimony of instinct, modifying it and forming one of the essential elements of its evolution." "It is probable that all the higher instincts had originally this intellectual quality." And yet Bouvier agrees with Bergson that instinctive behaviour is on a different tack from intelligent behaviour; they help one another; they are both "opposites and complements."

It is likely enough that Bouvier is right in believing that instinctive behaviour is manifold, and that it may be established as an innate capacity in more than one way. It is too soon to expect clear-cut conclusions in regard to these questions. But many will agree with the author in regard to the following three points. (1) There is in instinctive behaviour a psychical awareness as well as a physiological concatenation. "One can hardly see in insects simple reflex machines, for they know how to bend to circumstances, to acquire new habits, to learn and to retain, to show discernment. They are, one can say, somnambulists whose minds awaken and give proof of intellect when there is need for it. This takes us a long distance from the mechanism of which Bethe has made himself a protagonist." (2) Whether a capacity for novel instinctive behaviour originated from a sudden mutation or as the outcome of a more or less slow modification of habit, there must always be a period of individual apprenticeship, when the new card is played, or when the new adjustment is tested for what it is worth. (3) The climax of instinctive behaviour among arthropods is correlated with their characteristic organisation—a non-living armature of chitin with the musculature inside, not outside, and a considerable number of specialised appendages, which must be used in one way and in no other. "The appendages of Arthropods are nearly unchangeable in the individual and are narrowly adapted to certain purposes; they are the tools for instinctive work, thus differing from the less specialised but more supple limbs that serve as implements to the vertebrates, at least to the higher vertebrates." The contrast between a bee's specialised proboscis and a man's generalised hand is diagrammatic. So from the beginning, as Bergson also suggested, insects "were bound to use these organic tools, and they made the best use of them. Their main psychical task was to grave upon their memory and to repeat instinctively the acts to which these organs were fitted."

The fundamental part of Bouvier's masterly book is devoted to the analysis of the inclined plane of insect behaviour. He goes on to special problems such as the relation of insects to flowers, the faculty of orientation, the social life of insects, and the division of labour in nest-making Hymenoptera. Apart from a few slips, the translation, which cannot have been easy, is an effective piece of work.

Chemistry of the Plant Cell.

Chemie der Pflanzenzelle. By Prof. Dr. Victor Grafe. Pp. viii + 421. (Berlin: Gebrüder Borntraeger, 1922.) 105 marks.

THE title of this book raises immediately the interesting question as to whether the chemistry of the plant cell can yet be made the subject of a text-book. A perusal of this book leaves no doubt that such a work has still to be written. There are many interesting pages, but the book is in no sense an introduction to the special chemical metabolism proceeding within the plant cell.

The author treats his subject mainly from the point of view of physical chemistry, and the reader must, if the book is to be read with profit, be very thoroughly grounded in organic chemistry and bio-chemistry. Thus an interesting section on the cell wall, and a final subsection dealing with the chemistry of photosynthesis, are not accompanied by any discussion of the chemistry of the carbohydrates. Again, in a section of some 150 pages under the general title of protoplasm, ten pages only are assigned to the chemistry of lipoids (fats, phosphatides, sterols, etc.), proteins and nucleo-proteins; the same section closes with a subsection of some thirty pages, devoted to the pigments of the plant, which deal mainly with the recent researches of Willstätter upon the leaf pigments and the anthocyanins.

Lack of proportion is manifest throughout the book, and is accompanied by a lack of arrangement which leads to much tedious repetition. The main topics, diffusion, osmosis, plasma permeability, colloids, and adsorption, with which the book opens, recur again and again throughout its pages. Thus a later subsection headed plasma structure, in the section upon protoplasm, consists mainly of a rediscussion of the phenomena of plasmolysis and permeability. Undoubtedly these topics are of primary importance in a work upon plant physiology, but it is doubtful whether their significance in this field will be better apprehended as a result of the study of this book. The discussion of the physical chemistry of these complex phenomena is far too brief and inadequate to form a sound critical basis for their subsequent application to the still more complex problems of the living cell.

To cite specific cases: the first examples of adsorption phenomena dealt with, freely assume the specific adsorption of one ion from the solution of an electrolyte with consequent change in the reaction of the solution. The work of Baumann and Gully, and of Wieler, is cited in this connexion, and only upon a later recurrence of the topic is Sven Oden referred to in a footnote. Reference to Sven Oden's papers will show how unsound is the experimental basis for this assumption of specific ionic adsorption, while recent discussions by Bancroft ("Applied Colloid Chemistry," 1921) and E. A. Fisher ("Physico-Chemical Problems relating to the Soil," Faraday Society, 1922) show how inadequate are discussions of adsorption phenomena, based, as this one is, upon the application of Gibb's theorem without further reference to the chemical questions involved.

Again, a brief discussion of the Liesegang rings obtained when silver nitrate diffuses into gelatin containing potassium bichromate (p. 43), is made the starting-point for many suggestions as to the significance of these phenomena in explaining stratification in structural features of the cell and even of tissues. In view of our lack of information as to these diffusion phenomena, little significance can attach at present to the analogous appearances in cell structures referred to by the author.

The physical properties of protein sols and gels are discussed without reference to the reaction of the solution or the iso-electric point of the protein, the fundamental papers published by Jacques Loeb being ignored. Swelling and imbibition remain, therefore, very incompletely treated, and the interesting American work upon the importance of pentosans in the retention of water by plant mucilages is also neglected. The author refers, however, in his preface to the continued post-war difficulty in obtaining access to foreign literature, and doubtless these sections will undergo modification in a later edition.

The subsection upon enzyme action shows a similar lack of arrangement. It is to be hoped that the author's endorsement of Euler's suggestion that when enzymes are active as catalysts during synthesis they should be denoted by the suffix "*ese*," will not lead to an extension of the practice. His discussion of enzymes in relation to metabolic synthesis is unsatisfactory, but it at least makes clear how little reason there is for such a practice. Without a clear discussion of modern views of the stereo-chemistry of the hexoses, the discussion of the catalytic action of maltase and emulsin during synthesis is necessarily difficult, but it is curious to find no mention of the experiments of Bourquelot and Bridel, which had reached an interesting stage even in pre-war days. An interesting discussion of the action of hormones in relation to stimulus and response appears in this subsection upon enzymes. The subject reappears in a later section under the heading of response to stimulus, and here reference is made to the work of Paal, Ricca, and others, the absence of which in the earlier discussion had aroused surprise.

The attempt made to base the phenomena of stimulus and response upon physico-chemical phenomena provides some of the most interesting reading of the book, but it would appear hopeless to expect success in such an effort when the subject of the quantitative study of growth rate is compressed into less than two pages at the end of this section.

Scientific Management of Farming.

(1) *Farm Management: A Text-book for Student, Investigator, and Investor.* By Prof. R. L. Adams. (Agricultural and Biological Publications.) Pp. xx+671. (New York and London: McGraw-Hill Book Co., Inc., 1921.) 20*s.*

(2) *Organised Produce Markets.* By Prof. John George Smith. Pp. ix+238. (London: Longmans, Green and Co., 1922.) 12*s.* 6*d.* net.

(3) *Agricultural Co-operation in England and Wales.* By W. H. Warman. Pp. xi+204. (London: Williams and Norgate, 1922.) 5*s.* net.

(4) *Rural Organization.* By Prof. W. Burr. Pp. xiv+250. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1921.) 12*s.* net.

THE volumes before us emphasise the fact that farming involves two distinct kinds of operation, the production of crops and animals, and the marketing of the resulting commodities. Scientific investigators have in the past confined themselves almost exclusively to production, this being the side that involves the soil, the growing plant and the living animal, and with these almost all the sciences at present studied; it is quite evident, however, that there is a wide field for the economist in the marketing problems that will amply repay study.

(1) Prof. R. L. Adams deals exclusively with American conditions; his book is of a type that is not produced in this country, the old Fream in the past and some of the Oxford publications in the present being our nearest approach to it. It covers the whole range of the farm activities, largely from the economic side, but with constant references to modern improvements in production and the scientific principles on which they are based.

A great advantage of the book is the generous provision of tables of data showing crop yields, costs of production, effects of various factors on costs, on income, etc., with references to the original sources which will be at least equally appreciated. It is these data and references which give the book a special value to the teacher in this country, for he is thus enabled to ascertain how the values have been arrived at and how far they can help him in his work.

(2) Prof. J. G. Smith, of the Faculty of Commerce in the University of Birmingham, sets out in his book the general characteristics of organised markets and the broad principles involved in marketing operations. Considerable space is devoted to wheat and large-scale buying operations are discussed in detail. The volume is of interest as showing the extraordinary complexity of the processes whereby wheat is transferred from the Canadian farm to the English consumer.

(3) Major Warman deals more narrowly with the agriculturist and is concerned with an account of agricultural co-operation in England and Wales. He is convinced that co-operation is essential to the success of agriculture, and he is able to show that it is beginning to take hold on the rural community. Examples are given of farming societies, egg societies, dairy societies, etc., which are doing good work and have an undoubted future: we should, however, like to have seen some tables showing the amounts of produce handled, the financial turnover, etc. It may be the amounts are not large, but it is desirable that the data should be published.

(4) Prof. W. Burr discusses a wider problem, the organisation of the whole rural community in contradistinction to the urban population. It is widely recognised by American writers that the urban and rural communities are distinct, having different needs and requiring different methods of organisation. In this country the rural organisation has grown up through long ages and the urban population is the new problem: in America, however, the rural community is also new, and experts are studying closely the method in which it has developed, and feeling their way to some new organisation. The book is written for students, and it includes lists of questions and "research problems," which space, however, might usefully have been devoted to references to help those who wish to pursue the study of this interesting subject.

An Ideal Text-book of Physics.

Cours de physique générale à l'usage des candidats au certificat de Physique générale, au diplôme d'Ingénieur-Électricien et à l'Agrégation des Sciences physiques. Par Prof. H. Ollivier. Tome Second: Thermodynamique et Étude de l'Énergie rayonnante. Deuxième édition, entièrement refondue. Pp. 415. (Paris: J. Hermann, 1922.) 28 francs net.

FEW examination candidates are likely to base their studies on a book in a foreign language adapted to foreign courses; and it is therefore unnecessary to consider here the merits of this work for the purpose for which it is primarily intended. It will suffice to say that none but the ablest students could master it unaided. But as an exposition of the fundamental propositions of mathematical physics, from which those of us who have passed the examination stage may refresh our memories concerning what we once knew, or were officially credited with knowing, the volume exhausts our vocabulary of praise. There are no native works which profess to cover the same range, and few of any merit which cover part of it. We usually rely on Winkelmann or Chwolson. The former is far more encyclopædic, the latter more experimental; for M. Ollivier gives very few references and only such experimental facts as are necessary to illustrate principles; but in conciseness, lucidity and accuracy they are not to be mentioned in the same breath with our author. Even in completeness he is sometimes superior, for he enters more fully than most authors into some interesting byways of physics, such as luminescence, photometry and astrophysics.

The treatment is at once original and conservative. The order of historical development is usually abandoned completely and the subject developed in the full light of our present knowledge. Consequently, the science is presented deductively rather than inductively, the most general principles being stated first and their most important logical consequences (which are of course really their basis) gradually worked out. Whether this reversal of the usual sequence is desirable in teaching may perhaps be questioned, but there is no doubt of its efficacy in summarisation. On the other hand, there are no signs of the modern tendency to seek principles so broad and far-reaching that in gaining generality they almost lose physical significance. Thus the Boltzmann conception of entropy as probability appears only towards the end of the exposition of thermodynamics and the Nernst theorem appears mainly in foot-notes. But there is nothing old-fashioned about the book; if the author does not always pay so much attention as some would wish to the latest work, the reason is clearly a deliberate judgment of value and not mere ignorance.

But M. Ollivier's supreme merit in our eyes is that he really does write about mathematical physics. He does not give us either a treatise on pure mathematics which neglects the distinction between experiments which can, and those which cannot, be carried out, or a mere collection of familiar formulæ with "proofs" which prove nothing but the author's incapacity for accurate thought. He actually tells us how important magnitudes are measured and what is implied by the fact of their measurement; he realises that to define a magnitude and to say how it is measured are one and the same thing. Yet he does not fall into the opposite vice and weary us with needless pedantry; many readers will probably appreciate his abandonment of the old inadequacies and inaccuracies only by finding that, for the first time, they truly understand.

However, it is needless to continue in this strain. The present reviewer is not acquainted with the first volume of M. Ollivier's work and must confess that he had never heard of the work until it came into his hands for review. Many others are probably in a similar state of ignorance. The best that he can wish for the future of physics is that such a condition should become impossible, that "Ollivier" should become a household word and his treatise (if it is all equally good) be found in the library of every serious physicist.

N. R. C.

Science Primers.

(1) *First Course in General Science.* By Prof. Frederic Delos Barber and others. Pp. vii+607. (New York: Henry Holt and Co.; London: G. Bell and Sons, Ltd., 1916.) Price 9*s.* net.

(2) *The Science of Everyday Life.* By E. F. Van Buskirk and E. L. Smith. Pp. xvi+416. (London: Constable and Co., Ltd., n.d.) 7*s.*

(3) *A First Book of General Science: An Introduction to the Scientific Study of Animal and Plant Life.* By A. T. Simmons and A. J. V. Gale. (First Books of Science.) Pp. viii+145. (London: Macmillan and Co., Ltd., 1921.) 2*s.* 6*d.*

THESE three books offer a good contrast between British and American tendencies as regards general science in education. In the two countries, the movements in this direction have been going on independently. In both cases, they sprung from efforts made, in the 'nineties, in two or three schools, to take a bird's-eye rather than a toad's-eye view of science—to use the words of the Principal of one of the Illinois schools. In both cases, again, the growth of the movement began to be rapid about ten years ago.

With characteristic thoroughness, the Americans are fast reducing their methods to a system. In this country we are still in the muddle which seems to be our natural habit of growth. Now that examining bodies are issuing schedules of work to be done in this connexion, teachers may be forced to set their houses in order. Then, perhaps, the hardly-won freedom from traditional restraint may again be lost. It is to be hoped that the outcome will be more satisfactory in the way of awakening general interest in things scientific than the work of the last century proved to be.

(1) But to return to the contrast: in America, the teaching of general science is itself being developed into a science; in Britain, it remains an art. If in one case it might be more scientific, in the other it might well be more artistic. The book which Prof. Barber and his collaborators have written is among the best of its kind—and many good ones have been published across the water. It may even be objected that it is *too* complete. In a single column of the index, the following words occur: machines, malaria, maltose, meat, metabolism, monsoons, motors, mucor, mumps. Experience shows that anything like a proper assimilation of such mixed dishes occupies three or four years. Are the pupils to have the same text-book during all that time? Will not they tire of the style, the print, the binding? There is a certain value in change, if only for the incentive to make a new and better start. In such things, perhaps, the art of teaching lies.

(2) "The Science of Everyday Life" depressed us. It seemed such a good book spoiled—spoiled by the very riot of the science of teaching. Here we have done with chapters: the book is divided, instead, into two parts, five units, and eighteen projects. Every one of the latter is subdivided monotonously into introduction, problems, topics, and individual projects. A project, by the way, has been defined as a whole-hearted, purposeful activity proceeding in a social environment. Pupils may be expected to ask questions about their activities; but lest they should omit to do so, the authors give lists of questions which they ought to ask. When they have completed a project, the whole-hearted, purposeful, and active seekers after knowledge must feel that there is nothing more that they ought to know, can know, or want to know about it. Frankly, despite the authors' introduction, we can scarcely think of a surer way of killing initiative. Yet the subject-matter of the book is good, and teachers who are rather short of ideas might do well to study it. We ourselves found the diagram showing the various cuts in a side of beef instructive!

(3) "General Science," by Simmons and Gale, provides a refreshing contrast. Here the authors set out with a single aim: to make their young readers acquainted with the manner in which plants and animals live, and to describe some of the physical and chemical processes which are involved. A small book, the general purpose can be grasped by boys and girls; and they may hope to master the contents within a reasonable time. It is written as a man might write for men—children hate to feel that they are being written down to. The science of teaching does not obtrude itself upon the pages; which is not the same as to say that it is absent. That is where the art of teaching plays its part. The authors have compiled a book which is both sound and eminently readable. It is sure to find a wide acceptance.

C. L. BRYANT.

Atmospheric Electricity.

Électricité atmosphérique. Par B. Chauveau. Premier Fascicule: Introduction historique. Pp. xi + 90. (Paris: G. Doin, 1922.) 10 francs.

M. CHAUVEAU has set out to write a work on atmospheric electricity—a very laudable undertaking, for, as he says in his preface, there is no such work in the French or English languages, while there are only two in German. He proposes a work in three parts: (i.) historical introduction, (ii.) the electrical field of the atmosphere, and (iii.) ions, ionisation, and radio-activity. Part i. has now appeared, and if it may be taken as a fair sample of the whole, we may expect a very welcome addition to the literature of the subject.

M. Chauveau commences his history with the celebrated letter from Franklin to Collinson (dated 1750) in which the great American philosopher suggests a method for testing the hypothesis, then fifteen years old, that thunder and lightning are electrical phenomena. From this commencement the following stand out as the milestones along the path of progress:

(1) The proof that thunder and lightning are electrical phenomena: Dalibard, May 1752; Franklin, June 1752.

(2) The discovery of the electrification of the atmosphere with clear skies: Lemonnier, Sept.-Oct. 1752.

(3) The discovery of the daily variation: Beccaria, 1753–1775.

(4) The discovery of the annual variation: De Saussure, 1785.

(5) W. Thomson's (Lord Kelvin) improvements in instruments and methods, and the introduction of the idea of electrical potential gradient: 1856–1874.

(6) The discovery of the conductivity of air: Linss, 1887; Elster and Geitel and C. T. R. Wilson, 1899.

(7) The discovery of "atmospheric radio-activity": Elster and Geitel, 1902.

(8) The discovery of a very penetrating radiation in the upper atmosphere: Hess and Kolhörster, 1911–1914.

In telling the story of the progress from milestone to milestone, M. Chauveau has related the history of the development of instruments and methods and described the many attempts to find physical explanations of the phenomena observed. At first the observations were made with insulated conductors, generally pointed, from which sparks were drawn, but Lemonnier tested the electrical state of his "collector" by noting whether it attracted powder, and by this relatively delicate method he first detected "fine weather electricity." Later rough electroscopes, fitted with pith balls or gold leaves, made quantitative measurements possible, and so led to the determination of the diurnal variation by Beccaria. With electroscopes it was possible to detect a change in the electrical state of an insulated conductor as it was raised and lowered in the atmosphere (induction effect), and De Saussure used this method with remarkable results in 1785. It was with the discovery of "the power of the flame" to charge a conductor exposed to the atmosphere, which Volta made about 1780, that trustworthy methods became possible, but this discovery remained practically unused, and it was not until W. Thomson took up the study of atmospheric electricity some seventy years later that measurements were put on a sound physical basis.

Hypotheses and theories to explain the observations are innumerable: Volta's theory of the separation of electricity on evaporation; Peltier's theory of a permanent negative charge on the earth's surface, partially dissipated into the atmosphere by evaporating water and returned on condensation; Sohneke's theory of friction between water and ice; and Brillouin's theory of the electrical separation caused by ultra-violet light falling on the ice crystals of cirrus clouds; these are the most important. But every theory to explain the maintenance of the earth's electrical field has failed, and we appear to-day to be further from an explanation of this fundamental phenomena than we have been at any previous time. Even now we do not know whether the earth with its atmosphere is electrically neutral or whether there is a residual charge, and at the present moment there is not a single theory seriously maintained to explain the constant interchange of electricity between the earth's surface and the lower atmosphere.

G. C. S.

Forest Policy and Management.

(1) *Schlich's Manual of Forestry.* Vol. 1: *Forest Policy in the British Empire.* By Sir William Schlich. Fourth edition, revised and enlarged. Pp. xi+342. (London: Bradbury, Agnew and Co., Ltd., 1922.) 15*s*. net.

(2) *The Practice of Silviculture: With Particular Reference to its Application in the United States.* By Prof. R. C. Hawley. Pp. xi+352. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1921.) 22*s*. net.

(3) *Forest Mensuration.* By Prof. H. H. Chapman. Pp. xxii+553. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1921.) 30*s*. net.

(4) *A Short Manual of Forest Management.* By H. Jackson. Pp. x+70. (Cambridge: At the University Press, 1921.) 7*s*. net.

SIR W. SCHLICH has crowned a long life of devotion to the science and art of forestry by the publication of what is practically a new work, although it purports to be only a new edition of vol. 1 of his well-known Manual. (1) This volume is certainly the most valuable book on the economics and the history of British forestry that has yet appeared. It should prove interesting to the statesman and the economist, as well as to the forester and the industrialist.

The first part treats of general principles. The utility of forests is considered directly, when concerned with actual products, such as timber, turpentine, tans, etc.; and indirectly, when it is a question of the influence of forests on climate, soil erosion, hygiene, æsthetics and ethics. The last three are more important than is generally believed; and Sir William pleads for the creation of woodlands near large towns, which will serve as recreation grounds for the people and at the same time produce timber finding a ready sale, so that the establishment of these city forests need not be a financial burthen. Glasgow, renowned for its municipal enterprise, is the first of our cities to acquire a forest area for the enjoyment of its inhabitants, the Ardgoil Estate.

After the subject of the State in relation to forests is discussed, the remainder of the book, some 300 pages, deals with the actual condition of forestry in the British Empire. The British Isles, India, Canada, Newfoundland, South Africa, New Zealand, and the Crown Colonies are treated separately. The natural history of the forests, their resources in timber, the modes of silviculture, government policy, education, etc., are all carefully described, sketch maps and statistical tables being added where required.

(2) Considering the vast amount of information on the practice of silviculture which is scattered in British and American forestry journals and official bulletins, it is remarkable how few formal text-books on the subject have been published in English. The present work by a Yale professor is therefore very welcome. It deals primarily with conditions in the United States; but as the principles of silviculture are the same everywhere, the book can be used by British students with scarcely any change or comment. It is a compilation, remarkably up-to-date, and rendering matter available for study which otherwise could be found only by long search in German and French books. The author's presentation of facts is clear, and well illustrated by suitable diagrams.

There is, however, one serious defect, the omission of the subject of reproduction of the forest by artificial means, the reader being referred for information on this point to "Seeding and Planting," a companion book by Prof. Toumey, also of Yale University. Artificial planting of trees is much more common with us than natural regeneration; and the necessity of using another book will be irksome to British students. Prof. Hawley's exposition of the methods of natural regeneration is excellent; but the best chapter in the book is one dealing with "thinning," a difficult subject. Another subject, also treated in a fresh and original manner, is the disposal of the "slash" or rubbish which is left on the ground after felling operations. This is important, as on the removal of the "slash" depends in great measure the freedom of the forest from injury by fire, insects, and fungi. General measures of protection against these three agents of destruction, as well as damage caused by grazing, are treated in four short chapters.

An excellent feature of the book is an appendix of more than forty pages on terminology, which is really an alphabetical list with definitions of the terms used in the science and art of forestry. This glossary, which was drawn up in 1917 by the Society of American Foresters, will serve to stimulate accuracy of statement by foresters. German and French equivalents are given.

(3) Prof. Chapman's "Forest Mensuration" is the third text-book on forest mensuration which has appeared in English, and it is well designed to become the standard authority on the subject in the United States. The system of measuring timber in North America is totally different from ours. There, the contents of trees and logs are expressed in terms of the probable out-turn in sawn boards, according to a certain log-rule; hence the phrase "board feet." In the British Isles timber is measured as a raw material in terms of the real cubic volume. The American system introduces extraordinary complication into forest mensuration, some thirty log-rules being now in use in different parts of the country, no two rules giving the same result in board feet. A considerable part of the book is taken up with these log-rules and the principles underlying their construction—all of which is useless to the forester in Europe or India.

Nevertheless, a large part of the volume is of interest, for once log-rules are disposed of, the author is on common ground with his European fellow foresters, and gives a good account of recent developments of forest mensuration by Swedish and German writers. The accurate measurement of masses of standing trees is difficult, but is obligatory for purpose of valuation, and is of great use as a means of determining from time to time the increment of a growing wood. Upon a knowledge of the latter depends the fixing of the proper time for felling. Part III. deals with the laws of growth of stands of trees, and is by far the most interesting subject discussed, as the principles involved are the same in all countries where scientific forestry is practised. The preparation of yield tables and their application to predicting future yields are treated fully. The book will be useful in the reference library, but cannot be recommended as a handbook for British students, on account of its preoccupation with American practice.

(4) Forest management is little understood in the

British Isles, where owners of woods usually confine their attention to the practical work of planting, thinning, and felling trees, without having clear ideas of the financial problems involved. The objects of management are classified as being either physical or economic. The former apply to protection forests, maintained on mountain slopes to prevent erosion and mitigate disastrous floods, to forests on catchment areas that afford water supplies to towns, and to private woodlands on estates which are treated as amenity grounds for ornament and sport. An economic object of management applies to any forest worked for timber and other saleable products. Forests of this kind are commercial undertakings, and the scheme of management adopted here should be such as to render the woodlands a financial success, yielding the maximum soil rental and giving the highest net return on the capital involved. The principles underlying forest management are clearly explained in Mr. Jackson's little book, which can be recommended as an introduction to this important subject.

Thoughts on Scientific Advance.

Problems of Modern Science. A Series of Lectures delivered at King's College (University of London). Edited by Prof. Arthur Dendy. Pp. 237. (London: G. G. Harrap and Co., Ltd., 1922.) 10*s.* 6*d.* net.

THE object of this series of lectures is stated to have been to "place before the general public the present position of some of the main branches of science and to point out the direction in which progress is being made or may be hoped for in the near future." The book will also be found useful by scientific workers who desire to know something of the advances made in regions other than their own. The names of the lecturers are a sufficient guarantee of the value of the matter presented. It is unfortunate that no index is provided, and, for this reason, perhaps the most useful function of a review is to give some indication of the contents of the book. But it is to be understood that the topics mentioned by no means exhaust the list.

Prof. Nicholson's lecture on mathematics shows that much more research work is possible in that science, and it gives a useful account of the quantum theory. In Prof. Dale's astronomical lecture, we find a summary of the present position of the nebular hypothesis. It is interesting to find that certain kinds of nebulæ may reasonably be looked upon as bye-products of evolution. Prof. Richardson gives us a valuable general account of the latest views on the structure of atoms, and also further statements with regard to the quantum theory. Prof. Smiles refers especially to the chemistry of plants.

Prof. Dendy's lecture is an interesting discussion on the various component sciences making up that of general biology. A remark on page 131 with reference to the widespread influence of physiological considerations may be noted—"It is perhaps unfortunate that our interest in ourselves as human beings has resulted in the concentration of attention upon the functions of the human body, almost to the exclusion of the lower animals, so that the development of this branch of Biology has been a very lop-sided growth." It is to be hoped that recent developments, especially at the Plymouth Marine Biological Station, will remedy this state of affairs.

Prof. Ruggles Gates deals with various botanical problems, more especially with those of genetics and mutations. Prof. Halliburton is mainly concerned with pointing out the importance of free fundamental research in physiological science and gives various examples where important practical application at a later date was quite unforeseen. Prof. Barclay-Smith devotes his lecture to a useful account of the formation of bone, which presents phenomena of much greater general interest than some would be inclined to suppose.

The book may be thoroughly recommended, and the price is not excessive in comparison with many scientific works at the present day.

W. M. B.

Our Bookshelf.

The Newcomen Society for the Study of the History of Engineering and Technology. Transactions, Vol. 1, 1920–1921. Pp. 88+18 Plates. (London: The Newcomen Society, 1922.) 20*s.*

IN technology as well as in science the value of a knowledge of the history belonging to a given subject is gaining recognition. One result of the celebration at Birmingham of the centenary of James Watt in 1919 was the formation, by a few engineers interested in historical research, of the Newcomen Society, and the first volume of the society's Transactions has recently been issued. As indicated in its sub-title, the object of the society is to encourage the study of the history of engineering and technology, and it is, we believe, the first society formed for such a purpose. It takes its name from Thomas Newcomen (1663–1729), the Dartmouth blacksmith to whom we owe the atmospheric steam-engine. The honorary secretary and treasurer of the society is Mr. H. W. Dickinson, of the Science Museum, South Kensington.

Besides the papers read during the session 1920–21, the volume under notice contains the first presidential address, a list of members, the rules and constitution, and an account of the first summer meeting. Mr. Titley, in his address, after giving a brief sketch of the steps leading to the formation of the society, passes in review the subjects which come within its scope, points to the various activities open to its members, and emphasises the use of history in everyday work.

The first paper given is entitled, "Introduction to the Literature of Historical Engineering to the year 1640," and to this is appended a valuable bibliography of books relating to early inventions. Then follow interesting papers on "The Rise and Fall of the Sussex Iron Industry," "The Mystery of Trevithick's London Locomotive," and "The Invention of Roller Drawing in Cotton-spinning," all of which are illustrated by plates. The Transactions, which are well printed, will appeal, we think, to the general reader as well as the expert.

Espace, Temps et Gravitation : la théorie de la relativité généralisée dans ses grandes lignes. Par Prof. A. S. Eddington. Ouvrage traduit de l'anglais. Par J. Rossignol. Pp. xii+262+iv+149. (Paris : J. Hermann, 1921.) 28 francs net.

IN the introduction which has been written for this translation by Prof. P. Langevin we read : "Dès que m'est parvenu ce Livre où M. Eddington réussit à exposer de manière à la fois si simple, si vivante et si personnelle la marveilleuse transformation que le génie d'Einstein a introduite dans les conceptions les plus fondamentales de la Physique, j'ai pensé qu'une traduction en devait être faite pour permettre au public français de partager la joie que sa lecture m'avait fait éprouver.

"Une démarche immédiate m'apprit que l'initiative avait été prise quelques jours plus tôt par M. Jean Becquerel et que le travail était commencé dans les conditions les plus favorables, puisque je n'aurais pu proposer un meilleur choix que celui de M. Rossignol pour le traducteur, et que M. Eddington voulait bien s'assurer lui-même que les nuances, souvent délicates, de sa pensée seraient fidèlement rendues."

The French edition of Prof. Eddington's well-known book has thus appeared under ideal conditions, and it would appear presumptuous were one to express an opinion as to the merits of the translation. This edition is of greater length than the original English edition (see NATURE, vol. 106, p. 822, 1921), as it has been supplemented by a theoretical part in five sections as follows : I.—Elementary Principles ; II.—The Theory of Tensors ; III.—The Law of Gravitation ; IV.—The Mechanics of Relativity ; V.—Electricity. These sections are valuable additions to the original, and awaken regret that they were not included in the English edition. The translation will doubtless receive a warm welcome from our French colleagues.

Monograph of the Lacertidæ. By Dr. G. A. Boulenger. Volume ii. Pp. viii+451. (London: British Museum (Natural History), 1921.) 3*l.*

THE "Monograph of the Lacertidæ," by Dr. G. A. Boulenger, the first volume of which was published in 1920, is now completed by the issue of the second and concluding volume. In collecting the materials for this work Dr. Boulenger has not been content to rely entirely on the resources of the British Museum, but has travelled widely and far over all Europe and examined the collections of all the principal Natural History Museums. He has made a special point of searching for and examining for himself the type specimens of as many species as possible. The result is a monograph based on the examination of an immense material including the greater part of the actual type specimens.

Two features of this catalogue deserve special mention. The present whereabouts of the type specimens, where known, are given, information of the greatest value to future workers, and a full list of the specimens in the collections of the British Museum gives at a glance the resources of that Institution and should be particularly useful to specialists abroad.

The monograph is at once the most complete and the most authoritative on the Lacertidæ that has yet appeared, and will for a long time remain the standard work on the subject. It is, we believe, the last piece of work done by Dr. Boulenger in his official capacity at the British Museum. It is a fitting climax to the long series of catalogues and monographs on fishes, amphibia, and reptiles which have marked his great services to science at the British Museum.

British Museum (Natural History) Economic Series, No. 13. *Mites Injurious to Domestic Animals (with an Appendix on the Acarine Disease of Hive Bees).* By Stanley Hirst. Pp. 107. (London: British Museum (Natural History), 1922.) 3*s.*

THIS profusely illustrated little book on the mites infesting domestic animals is the thirteenth of the series of pamphlets on economic entomology issued by the British Museum (Natural History). Like its predecessors, it is designed on strictly practical lines, and the subject-matter cannot fail to appeal to a wide circle of interested readers, from the systematic entomologist and experimental pathologist to the breeder and fancier, be it of horses, cattle, pigs, dogs, rabbits, fowls, or bees. A little more than half of the book is devoted to the important family Sarcoptidæ and the various species of mange for which members of this family are responsible. Useful hints on the treatment and management of infected stock are supplied, and wherever these parasites have been known to transfer their attentions to human beings, the fact is mentioned. Parasites of this order may prove to play an important part in the transmission of infectious disease, not only from animal to animal but from animal to man ; and to the medical or veterinary entomologist searching for a possible transmitting agent of some obscure animal plague, the accurate descriptions and illustrations supplied in this book will be very helpful. An interesting feature is the appendix devoted to the description of "Isle of Wight" disease (Acarine disease of bees) and its causation by the mite *Acarapis woodi* which inhabits the tracheal tubes of infected bees.

The Changing Year. By Anthony Collett. Pp. viii+310. (London : Hodder and Stoughton, Ltd., n.d.) 15*s.* net.

MR. COLLETT has done well to collect his delightful Nature essays, originally contributed to the *Times*, and to publish them in this more permanent form. They are worthy of preservation, for Mr. Collett is a field naturalist of first rank. He has a keen and accurate eye for observation and an ear tuned to record the music of Nature which he hears around him, and he combines with these a gift of expressing what his senses have appreciated in simple yet delightful language which cannot fail to awaken in his reader that intense enthusiasm and love for Nature which he himself undoubtedly feels.

In this book Mr. Collett guides us pleasantly through the year, pointing out the sign-posts which mark the progress of the weeks and months: the awakening of the spring, the arrival of the birds on spring migration, the intense bustle and activity of the early months of the year, the quieter and more matured beauty of summer, the renewed activity of autumn with its preparation for the winter, and the calm peace of the winter months with always the promise of spring and life.

The book is full of useful facts and details which only the true field naturalist can acquire and observe. We regret that there is no index by means of which ready reference to these first-hand observations can be made.

Radio Receiving for Beginners. By Rhey T. Snodgrass and Victor F. Camp. Pp. 99. (London: Macmillan and Co., Ltd., 1922.) 3*s.* 6*d.* net.

THIS is a work professedly intended for those with very limited knowledge of wireless matters, but the author, in his endeavour to avoid technicalities in the introductory portion, has rather missed the opportunity of presenting the elements of the subject in a sufficiently tangible form for the reader, if really unacquainted with the principles of wireless working, to pick up readily the full meaning of the excellent chapters which follow. In these, we are conducted progressively through crystal reception, plain valve reception, regenerative working, and single and double valve amplification. A good typical arrangement of connexions is given in each case, but it is understood that many variations can prove equally satisfactory. All this part of the book is thoroughly practical, and its utility is not greatly interfered with by the fact that it refers to American conditions alone. The general hints and the chapter on aerial construction are full of useful points, and explanatory notes on some of the individual pieces of apparatus which make up the complete equipment are contained at the end. The author makes it amply clear that wireless reception requires care, skill, and practice to get really good results, and is a good deal more than buying a complete outfit and "listening in" with a telephone.

Applied Calculus: An Introductory Text-book. By F. F. P. Bisacre. Pp. xvi+446. (London: Blackie and Son, Ltd., 1921.) 10*s* 6*d.* net.

THE adjective "applied" is used by Mr. Bisacre to imply "the treatment of practical problems being preceded by a fairly full discussion of the necessary theory." We thus get a competent elementary account of the differential and the integral calculus, followed by applications to curves, maxima and minima, electricity and magnetism, chemical dynamics and thermodynamics. The chapter on electricity and magnetism is too short, while that on thermodynamics is quite long. An attempt is made to clear up the mystery of limits, but the success would be more certain if the example used for the purpose were not the rather trivial one of finding the limiting value of x^2 when x becomes equal to 10. It is doubtful whether "epsilonology" is at all in place in such a book, and the practical student will scarcely be impressed with its value in view of the author's treatment. The tables should have been more extensive; as they stand their usefulness is very limited.

Interesting features of the book are photographs and biographies of pioneers in the calculus and its applications. The mottoes at the heads of the chapters are often cleverly chosen, like "A snapper-up of unconsidered trifles" for the chapter on integration.

S. B.

The Care of the Adolescent Girl: A Book for Teachers, Parents, and Guardians. By Dr. Phyllis Blanchard. Pp. xxi+201. (London: Kegan Paul and Co., Ltd., 1921.) 7*s.* 6*d.* net.

IN her foreword to this book, Dr. Phyllis Blanchard explains that its object is to help teachers, parents, and guardians to provide adolescents with definite information concerning their own nature and to point the way to a proper utilisation of their energies.

After introducing the views of various authorities, Dr. Blanchard considers the instincts of the adolescent girl and the resulting conflict and repressions, and later, the pathological results of these repressions. The most important chapter is that devoted to the sublimation of the sex factor into other activities.

It appears that the author considers the adolescent conflict as entirely sexual in nature; but its solution, which may be described as an adjustment to the perpetual mate, is not the only one in which the guardian and teacher must assist. The adjustment to society, the failure in which gives us the recluse, the crank, and the social rebel, is practically ignored. An adjustment to the conception of the infinite, failure in which leads to the conflict found in nearly all agnostics and materialists, is only dealt with as a method of sublimation of the sex factor; from this point of view the author evolves a Christianity which, as Dr. Scharlieb states in her preface, is scarcely to be recognised as Christianity by those who have been brought up in any of the orthodox schools.

Hyperacoustics. By John L. Dunk. Division II. Successive Tonality. Pp. xi+160. (London: J. M. Dent and Sons, Ltd.; New York: E. P. Dutton and Co., 1921.) 5*s.* net.

THE first division of the author's work, "Simultaneous Tonality," was published in 1916 and was shortly afterwards reviewed in these columns (vol. 98, p. 306, December 21, 1916). At least one-third of the present volume is devoted to a "brief résumé" of the earlier book, and then the author passes on to the new aspect of his subject, "Successive Tonality." The method of treatment is similar to that adopted previously, and there is little to add to the notice of the first volume. The nomenclature is so complex that a glossary, occupying six pages of the text, is provided for the convenience of the reader. The author recognises the difficulty clearly: "The jargon of each particular science is a real obstacle, not only to the acquisition of knowledge, but to the sympathetic understanding by workers in parallel fields, who, occupied with their own formulæ, tend to be repelled when confronted with the hieroglyphics of a sister science." The present reviewer is unable to agree that the "jargon" here employed is likely to promote clear thinking, and does not believe that it will ever form the basis of a common language among all who are interested in the subject.

Handbook for Field Geologists. By Dr. C. W. Hayes. Third edition, revised and enlarged by Sidney Paige. Pp. xi + 166. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd, 1921.) 13*s.* 6*d.* net.

DR. HAYES's manual, well bound, with rounded corners and gilt edges, is clearly intended for the pocket or the haversack. It is based on the methods adopted by the United States Geological Survey, and covers a certain amount of simple topographic surveying for ascertaining correct positions. The diagrams to illustrate forms of outcrop are small, as is necessitated by the size of the page, and we may prefer the bolder treatment given to this subject in Dr. Elles's recently published "Study of Geological Maps." Some matters, such as the description of common minerals in Appendix I., with its old-fashioned chemical formulæ, might have been left to the text-books with which the surveyor must become acquainted before he goes into the field. The directions as to the collection of the remains of fossil vertebrates and the investigation of placer deposits will rouse feelings of envy among those whose work is confined to the British Isles. But is the work of a geologist ever so confined? For those who are true geologists because they travel, Mr. Paige has provided a compact and handy guide. It points out, at any rate, on what details attention should be fixed. G. A. J. C.

The Psychology of Medicine. By Dr. T. W. Mitchell. Pp. viii + 187. (London: Methuen and Co., Ltd., 1921.) 6*s.* net.

THIS book is intended primarily for those who, without being students of medicine or psychology, wish to keep themselves abreast of modern thought in these subjects. The earlier chapters are devoted to a discussion of the various psychological theories, commencing with Janet's theory of dissociation and its connexion with hysteria and the hypnotic state, and then passing on to Freud's theory of repression. The rest of the book deals with the conception of the unconscious, with psycho-analysis, and with the classification, treatment, and prevention of neuroses. Psycho-analysis is described from three aspects, namely, as a method of investigation, as a doctrine of the content and process of the mind, and as a therapeutic method.

The clearness and impartiality with which Dr. Mitchell has considered conflicting views will be appreciated by the reader who requires only a general outline of modern psychology. A few notes are appended for guidance in selecting literature for further study of the subject.

Graphical Analysis: A Text-book on Graphic Statics. By W. S. Wolfe. Pp. xiv + 374. (New York and London: McGraw-Hill Book Co., Inc., 1921.) 20*s.* net.

MR. WOLFE offers us a detailed study of the graphical methods as used in statical problems, with applications to the investigation of various types of structures. He first sets out the ordinary theory of force and funicular polygons. The graphical processes for finding centres of gravity, moments, and moments of inertia come next, and then bending moments and shearing stresses of beams. Frameworks follow, applied to all kinds of trusses, roofs, and arches. After a chapter on moving loads on bridges we get the study of masonry piers and masonry arches as well as of reinforced concrete. A chapter on design of beams and struts, and a chapter on miscellaneous problems, complete an exhaustive account of a most important subject. There are more than 700 diagrams, all very well drawn and reproduced. It is difficult to see what advantage there can be in using A-B to designate the line AB, or A-B-C to designate the angle ABC. In view of the alarming increase in the prices lately charged for scientific books, it is a pleasure to note the excellent get-up of Mr. Wolfe's book and its moderate price. S. B.

The Horniman Museum: A Handbook to the Collections illustrating a Survey of the Animal Kingdom. By H. N. Milligan. Second edition. Pp. 66. (London County Council, 1922.) 6*d.*

THIS is really an elementary account of the animal kingdom on the usual lines of descriptive zoology. It does not seem to refer definitely to any particular specimens placed on exhibition; but no doubt most of the forms mentioned are on view in the museum cases and serve instead of drawings. The statements are generally accurate and as precise as brevity permits. The style is clear, but assumes some familiarity with words not in the vocabulary of the general visitor, such as "retractile," "aberrant," "everted." If the class Myriapoda is retained, this is merely an instance of the "conservative attitude found convenient in a handbook to be used by the general public." To say that *norvegicus* and *rattus* are "specific names" is but to share a common error, and if the phrase "the Theromorpha contains" is a grammatical howler, it is the only one of its kind in this book. Mr. Milligan has accomplished a difficult task with much success.

Radioactivity and Radioactive Substances. By Dr. J. Chadwick. (Pitman's Technical Primer Series.) Pp. xii + 111. (London: Sir Isaac Pitman and Sons, Ltd., 1921.) 2*s.* 6*d.* net.

SIR ERNEST RUTHERFORD's words of commendation in the Foreword to this little book are well deserved. "It is a clear and accurate account of radioactive phenomena written by one who has a first-hand knowledge of the facts." "To all those who are interested in the development of our knowledge of this fascinating subject I can strongly recommend this book as a simple, concise, and accurate statement of the main facts and theories." The diagrams are numerous, and, though on a small scale, are remarkably clear. Similar volumes on other branches of modern physics would be welcome.

The Rural Community. By Llewellyn MacGarr. Pp. xv + 239. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1922.) 8*s.* net.

THIS book deals in a very elementary fashion with the social and economic factors affecting the agricultural worker, and its chief merit is its extreme simplicity.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Primitive Crust of the Earth.

PROF. COLE's letter in NATURE of July 8, p. 39, concerning the earliest known rocks—a group of sediments—and their relation to the ortho-gneisses, will, I think, call forth the sympathy of students of African geology. In 1904–1905 I came to the conclusion that the para-schists of Southern Nigeria were older than at least the majority of the ortho-gneisses, and searched—without success—for the real foundation-stones which received upon their surface these earliest sediments.

Later I have suggested that the Turoka Series of para-schists of Kenya Colony may prove the oldest rocks of that part of Africa and have thought that, were the main directions of foliation of the ortho-gneiss mapped throughout that continent, we should find, not directions produced by dynamic metamorphism, but directions indicating the upwelling of granitic bathyliths along zones of failure of the primitive crust, *i.e.* foliation swirls on a huge scale akin to those produced by the flood of the Laurentian magma around the disrupted blocks of Grenville sediments. It might be possible to tell what section of the eroded complex was being studied by observations on the frequency of the occurrence of syntectics, the degree of admixture, the proportion of reconstituted sediments to ortho-gneiss, or even by a passage from complete to less complete metamorphism in the invaded rocks.

The newly established surveys of Uganda, Tanganyika Territory and Nyasaland will, one hopes, throw a flood of light upon this fascinating problem of the constitution of the African Archæan.

JOHN PARKINSON.

Athenæum Club, S.W.

Action of Cutting Tools.

MR. MALLOCK's theory of cutting tools (NATURE, August 26, p. 277) is extremely illuminating, but the term "Coefficient of Friction" in his final paragraph seems scarcely justified, as it would imply that the shearing force is always in the same direction and thus independent of the material being cut, of the depth of the cut, rate of feed and tool angles.

In practice even among skilled workers there is considerable variation in the tool angles used, and there is no decided preference by the workman for a tool ground on a fine-grained emery wheel as against one ground on a coarse grindstone; this on very heavy work where the friction might be important. Moreover, the general variation in practical tool angles seems more related to what may be termed the pliability of the material. Thus, for mild steel and wrought iron, angles of 50° to 55° are common, for cast-steel and cast-iron 60° to 65° or 70° are the rule, whereas the brass-finisher's tools are almost flat topped with an angle of 80° to 85°. Copper and aluminium turnings bend very nicely, and thus the sharp tool angle required for them agrees with the pliability theory.

This idea of pliability is not antagonistic to Mr. Mallock's main argument but strongly in support of it, for when a metal yields pliable turnings, these turnings slide on the upper face of the tool a great deal more than when they break off short as in a friable material. Thus the curly turnings of a pliable material may exert more frictional force on the upper face of the tool, but not necessarily because the coefficient of friction is higher. Pliable turnings can slide and thus cause friction: brittle turnings break off with very little sliding. This may be seen very clearly in the rough turning of gun barrels. With certain tool angles and not too heavy a cut, the turnings curl off and are hot, whereas with a more obtuse tool and even a heavier cut the metal crumbles off and is probably not so hot. In the latter case the surface turned has a corrugated periphery showing the periodic impulsive friction on the tool face. The friction theory thus leads to a plausible explanation of certain forms of "chatter." If the friction on the tool face fluctuates on account of either vibration or crumbling of the cutting, and if the system has a natural period in tune with what may be termed the crumbling wave-length, resonance occurs.

But for practical difficulties Mr. Mallock's theory might be of value to investigators of friction, for in no set of actual conditions is it likely that metal slides on metal with more intimate contact than near the point of a cutting tool. Even with cutting lubricants it is doubtful if any liquid reaches the point of the tool unless there is chattering.

In attempting any conception of coefficients of friction between the tool and the cuttings, a further difficulty arises which renders the comparison with clean dry surfaces almost impossible. In some circumstances the cutting of metals produces, in addition to the obvious turnings, a fine smooth powder. This is presumably produced by the abrasion of the cutting on the upper face of the tool, and it may be that this smooth powdered metal acts as a lubricant or ball-bearing for the escaping turning. If so, it would be another of Nature's modes of automatic alleviation—as tears allay the irritation of dust in the eyes, and as the skin is cooled by evaporating sweat.

H. S. ROWELL,
Director of Research,
Research Association of British Motor and Allied Manufacturers.

15 Bolton Road, W.4, August 27.

The Smoke of Cities.

WITH reference to Prof. Cohen's article on smoke abatement in NATURE of August 26, p. 269, I should be much interested to know why Manchester smoke is qualitatively so much worse than London smoke. Comparing Guy's Hospital and Gower Street with the University of Manchester—the three places of which I have had sufficient experience to judge—I should judge that the quantity of dirt in one's laboratory is about the same; at any rate it is not obviously less in London and, so far as I remember, the published measures of atmospheric pollution confirm this impression. But the Manchester dirt is far more unpleasant and destructive to one's hands, papers, and apparatus. It seems to contain more very fine sticky particles, which get in everywhere and are difficult to clear off: the London dirt is more gritty and granular, makes things dirty enough but is comparatively easily removed. Any one who has spring-cleaned laboratory cupboards in the two places and essayed afterwards to clean themselves will have realised that the dirts are of quite diverse characters. From what Prof. Cohen says I should judge that London smoke is relatively less domestic in origin than the Manchester product, but it seems difficult to reconcile this with what one knows of the two places. Does the sort of coal make a difference, or the length of time it is kept before consumption? Or is much of the London dirt dust from other sources than coal fires, dispersed more widely than in the damper Manchester atmosphere?

A. E. BOYCOTT.

Medical School, University College Hospital, London, W.C., August 28.

PROF. BOYCOTT'S statement is rather surprising; but I cannot think that the explanation is to be found in the larger amount of domestic smoke in Manchester. One would rather expect the reverse, and I can only suppose that the difference between Manchester and London dirt is due to the larger amount of dust not arising from smoke, as Prof. Boycott suggests. Any difference in the quality of coal used in Manchester and London would scarcely have the effect he describes.

The point is an interesting one and I think could be settled by microscopic examination of specimens from the two towns. Soot is easily identified in this way.

J. B. COHEN.

Thwaite Cottage, Coniston Lake, Lancashire, September 1, 1922.

Waterspouts.

WATERSPOUTS on Lake Victoria are very commonly seen from Entebbe, but at a long distance away, and though I have worked on the lake shores for nearly four years it was only two days ago that I first saw one near enough to be of real interest.

I was in camp on the north end of Bugalla, the largest island of the Sese Archipelago. The camp lay about 300 yards from the shore of a small bay. At daybreak on June 30 there were very lowering black clouds and every indication of an immediate heavy storm. While looking out from the tent I suddenly saw that a waterspout was travelling obliquely towards us, and as it eventually came to within about 100 yards of the shore a very good view was obtained for about five minutes before it came to an end.

The pedicle arose from a well-marked circular area on the water, which was otherwise only faintly rippled by the preliminary puff of wind before the approaching storm.

This circular area was evidently very violently disturbed as a cloud of vapour, greatly agitated, rose from it for a little distance.

The pedicle was extremely narrow at its lower end, and not quite straight, being sinuous in outline. It broadened out gradually into a column which went up into the low cloud; the core of this column was much less dense than the periphery, and the violent upward spiral ascent of the water could be clearly seen.

So far I have described nothing unusual, but the following was quite new to me and seemed of great interest.

Surrounding the central core, but separated from it by a clear narrow space, was a sheath, the lower end of which faded away some distance above the water. The profile of this sheath was undulating, it being thicker in some places than others. A curious point is that this sheath *seemed* to pulsate rhythmically, but I could not say whether the appearance of pulsation might not have been an illusion caused by waves travelling up its outer surface.

This pulsation gave an uncanny suggestion of a live thing, which was aided by the violent spiral movement upwards in the central core, the clouds of vapour boiling round its base, and the movement of the whole across the water—indeed, we watched it spellbound until the pedicle dissolved away at the bottom, and the ascent of the part above brought the phenomenon to an end.

My wife watched with me, and is in entire agreement about the curious appearance of pulsation of the outer sheath.

Fig. 1 is a reproduction of a pencil drawing which

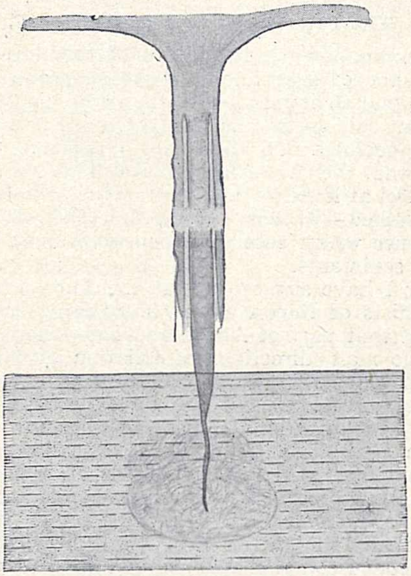


FIG. 1.

may give some idea of what we saw. I cannot estimate the height to which the column rose. Its cessation was followed by violent rain and thunder.

G. D. HALE CARPENTER,
Uganda Medical Service.

Entebbe, Uganda, July 1.

DR. HALE CARPENTER'S letter brings out one feature which has never, to my knowledge, been noted in a waterspout, namely, the sheath, separated from the main body of the whirl by a clear space. Wegener, in his book on "Wind- und Wasser-hosen in Europa," gives illustrations of a large number of waterspouts, but in no case is there mention of two trunks one within the other. The nearest approach to the phenomenon noted by Dr. Hale Carpenter is the not infrequent occurrence of waterspouts which show two clearly defined parts, an upper thick column with a lower whirl of much smaller thickness.

The accepted explanation of waterspouts is that they consist of whirls in rapid rotation with a discontinuity at the outer boundary. The rotation produces a rapid lowering of pressure within the whirl, and consequently a lowering of temperature, which may easily be sufficient to bring the air in the whirl down below its dew point. This is sufficient to explain the main features of the typical waterspout. The amount by which the temperature is lowered decreases outward from the "axis" of the whirl, while the difference between the air-temperature and dew point normally increases downward from the cloud level. The thickness of the visible column or zone of condensation therefore diminishes downward, giving the form of an inverted cone of irregular shape. Near the water the air is again near saturation, and the difference between air temperature and dew point is small, so that the base of the whirl is widened. It frequently happens that the portion at middle heights is not visible, on account of the relative dryness of the air.

F. J. W. Whipple (*Meteorological Magazine*, February 1922), writing on cloud pendants, shows that within a whirl of 20 metres diameter, rotating once in a second, with a lowering of pressure of 30 mb. at the centre, the maximum wind speed would be 70 metres per second, or 160 miles per hour, in agreement with winds estimated in tornadoes. A deficiency of 30 mb. pressure represents a suction sufficient to support 1 foot of water only. The solid appearance of a waterspout is therefore not to be ascribed to the lifting up into the air of a solid column of water, but is due partly to the condensation of water vapour within the whirl itself, and partly to water drops which are carried upward in spiral paths. This upward motion of water drops is a well-marked feature of most waterspouts.

The existence of an outer sheath, separated from the central core by a clear space, would appear to require a discontinuity of water content of the air, symmetrical about the axis of the whirl. It does not appear possible to explain it even as the effect of discontinuities of velocity within the whirl. No physical explanation of this clear space can be suggested.

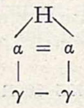
It is usually suggested in text-books (for example, Humphreys's "Physics of the Air," p. 213) that waterspouts are formed at the boundaries of wind currents of different directions. But as such boundaries are of considerable extent, it is difficult to understand why single waterspouts ever come into existence. One would rather expect to find large families of waterspouts distributed over a considerable area. It is true that usually several are seen at the same time, but isolated cases are not infrequent.

The fact that Dr. Hale Carpenter, while standing within about one hundred yards of the waterspout he describes, apparently felt no wind from the whirl, testifies to the very limited diameter of the whirl in question. D. BRUNT.

Meteorological Office, Air Ministry,
Sept. 1.

Periodic Structure of Atoms and Elements.

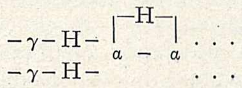
A. C. CREHORE, in his recent papers on "The Hydrogen Molecule" in the *Philosophical Magazine* (October 1921, May 1922, and June 1922), makes use of the specially constituted atoms of hydrogen and helium discussed by him, and of a hypothetical atom, the atomic weight of which is $2\frac{1}{3}$, to build up some of the other atoms. He uses H particles, hydrogen with charge $+e$; α-particles, helium with charge $+2e$; and particles of his hypothetical element, with positive charge $+e$. I think it is clear that he recognises the need for a helium particle with positive charge $+e$ in addition, if neutral atoms are to be built up in the way he indicates. In one of his models one of the particles marked 4 is also marked with a dot, and this evidently means that it has a charge $+e$ only. Calling these particles γ, glucinum or beryllium becomes α, γ, H and its structure appears to be $\gamma = \alpha = \mathrm{H}$, where the hyphens indicate electrons. Its isotope, of atomic weight 12, is $-\gamma-\mathrm{H}-\gamma-\mathrm{H}\ldots$, forming a simple ring of unit-charged particles. Nitrogen is 2α, γ, 2H, and may have the structure



Fluorine, instead of having the constitution assigned to it by Crehore, may be 2α, 2γ, 3H, and may have either of the two following structures:

$$=\alpha\begin{matrix}-\gamma-\mathrm{H}-\mathrm{H}-\\-\quad\gamma-\mathrm{H}\quad-\end{matrix}\alpha \;\vdots\;\vdots\;\vdots$$

the α's joining up to form a ring, or



the two γ's joining up to the α on the right to form a ring.

Starting from the element of lowest atomic weight in each of the groups of the periodic table, I have found it possible to build up all the other elements of these groups, with atoms of distinctly similar structure for each group, and marked differentiation between the different groups. This has already been carried out up to uranium for nearly all the groups, so that hypothetical models, of the correct atomic weight and atomic number, could now be constructed for the majority, and probably for all, of the known elements and their actual and probable isotopes. Uranium (U.I.) has been assigned the structure

$$=15\alpha\begin{matrix}-7\gamma-\\-7\gamma-\end{matrix}15\alpha\begin{matrix}-7\gamma-\mathrm{H}-\\-7\gamma-\mathrm{H}-\end{matrix}\alpha=$$

forming a ring-shaped chain of thirty-one α-particles joined up by two equal chains of 7γ particles and two other equal chains of 7γ and one H particle. This type of structure may be assigned to elements of Group VI. H. NEWMAN ALLEN.

3 Lexham Gardens, Kensington, W.8,
Aug. 26.

Transmission of Sound of Explosions.

READERS of NATURE may be interested to know that a Commission appointed a year ago for investigating the transmission of sound of explosions is arranging for an experiment on this subject to take place on a day to be notified as soon after September 23 as the weather will permit.

On this occasion it is the War-Minister of the Netherlands who has been able to assist the Commission by notifying it of the intention to explode, on the day to be appointed, some 10,000 kilogrammes of perchlorate of ammonium at 19·30 (western European time); the main explosion will be preceded by a small explosion of a mass of 500 kilogrammes at 19·25.

I learn these particulars from Prof. Van Everdingen, director of the Meteorological Service of the Netherlands, who tells me that the countries surrounding the locus of explosion—Oldebroek, Lat. 52° 29′ 56″ N., Long. 5° 59′ 40″ E.—within 500 kilometres, are being invited to instruct their observers to watch for evidence of the explosion.

NAPIER SHAW.

Sept. 18.

Research and Razors.

THE incident referred to by Principal Irvine (NATURE, Sept. 16, p. 385) may have been in connexion with Faraday's work on special steels. These were not, I think, a success so far as their use for razors is concerned, so that the present was appropriate. In any case Faraday had little to complain of, since the modern manufacturer does not send even razors.

J. R. PARTINGTON.

45 Kensington Gardens Square, W.2.
Sept. 16.

Human Geography: First Principles and some Applications.[1]

By MARION I. NEWBIGIN, D.Sc.

IT is a curious fact that, although geographers are agreed that man's intelligence and power of acquiring and transmitting knowledge so differentiate him from animals that it is necessary to distinguish between human geography and animal geography, yet, so far as I am aware, little detailed consideration has been given to the question as to the respects in which his response to environmental conditions differs from that of the animals. This is unfortunate, more especially since, thanks to the biologists, we have a fairly clear idea as to the mechanism of the response in the latter case.

If, for example, we take two familiar animals, such as the rabbit and the common hare, we find that, though belonging to the same genus, and generally resembling each other in structure, they show certain minor differences in bodily form and habits fitting them for their respective environments. The biologists are broadly agreed that these differences are an adaptive response to the different environments of the two animals. In explaining the origin of that adaptive response, most of them lay stress on the two factors of fixation to a particular environment and isolation—actual or physiological—within it, so that incipient variations are not swamped by intercrossing. Now when we turn to man, two facts are at once apparent. First, at the present time, he does not appear to respond to environmental influences by adaptive modifications of bodily form. Secondly, there was certainly a time, before he had come fully to his heritage, when he did so respond. We know this because the anthropologists are agreed that while man once ran into a number of species—and of genera—now all living human beings belong to the same species, and even the races show marked signs of being in process of becoming swamped by intercrossing. In other words, there was a time when there was no human geography, when man reacted to the sum total of the conditions as an animal does; but that time appears largely to have passed.

But there is certainly still a human response to environmental conditions. What precise form does it take? To a certain minor extent, apparently as an inheritance from what I regard as essentially the pre-human period, there is a direct structural response. But man's real response to the surface phenomena of the earth takes the form of a communal, not an individual response. It is the aptitudes which the members of a community display, the tools which they use, the kind of knowledge which they accumulate, their modes of organisation, their type of material wealth, their traditions and ideals, which show the environmental imprint most closely—far more closely than the colour of their skins or the shape of their heads.

But when and how did the change in the two modes of response come about? To answer this question let us recall what has been already said as to the importance of fixation and isolation in the case of animals. The surface of the earth is almost infinitely diverse, and what the biologists call natural barriers, the major barriers like deserts, seas, and mountain chains, or the minor ones produced by the transition from one type of plant formation to another—*e.g.* from the forested river valley to the grass-covered upland—separate different types of environment, and form obstacles to the distribution of most land animals. There must have been a time when groups of men, no less than the pigs in the forest or the asses on the steppe, were firmly gripped by the physical conditions, were isolated from other groups, and forced to become fitted by structure and habit for a particular set of conditions, or to die out. But with his growing intelligence man escaped from this iron grip, learnt to make virtually every part of the surface yield enough for survival, and proved capable of overcoming every kind of natural barrier. When this occurred the old mechanism of adaptation largely—though not completely—ceased to work. Evolution then might have ceased also, man might have become specially fitted to no environment because fitted for all, if the factors of fixation and isolation had not, in quite a different fashion, obtained a new hold.

Man ceased, save in relatively few parts of the earth's surface, to be a continuous wanderer. He settled down afresh on particular parts of it, and there learnt to use his increasingly complex brain not only in utilising to their full the natural resources, but also in modifying the local conditions so that new resources became available. In other words, I wish to suggest that the cultivation of the soil was the great agent in ensuring the new type of fixation to a particular area which once again made evolution possible. But evolution now took the form of increasing development of communal life, or, in other words, the growth of what we call civilisation is the precise equivalent of specific differences in plant or animal.

Further, just as, in the case of the animal, isolation is necessary before an incipient species can become fixed, so in the case of human communities a measure of protection from the inhabitants of neighbouring areas—a measure, that is, of isolation—is essential before civilisation can develop.

Again, in the case alike of plants and animals we know that where the local conditions are such that the incipient species is limited to a very narrow area, highly specialised forms of adaptation may occur, as they do, for example, on many islands, or in isolated mountain chains; but that specialised type of development is associated with the loss of the capacity to vary, to acquire adaptations fitting the organism for a wider area. So in the case of human communities, where the isolation is too complete the power of adaptation tends to be lost, and such groups, though their civilisation may, along its own lines, be of a highly specialised type, are easily overwhelmed when contact with the outside world does occur, just as island animals tend to disappear before introduced forms.

With these general statements as starting-point, let us consider some facts in regard to the development of civilisation in Europe and the margins of the adjacent continents.

In this area history has seen three successive great

[1] From the Presidential Address delivered to Section E (Geography) of the British Association at Hull on Sept. 7.

foci of civilisation, each based on well-marked and distinctive geographical conditions. The development of the three types has been successive and not simultaneous, and there has thus been a steady shift in time of the main focus, a shift westward and north-westward. The three types of human societies alluded to are, of course (*a*) the river valley type as represented in Babylonia and early Egypt; (*b*) the Mediterranean type on parts of the seaboard of the Midland sea; (*c*) the forest type of Europe proper, itself becoming progressively more and more influenced by the greater ocean to the west, so that forest influences have steadily given way to maritime ones.

It is not necessary to consider the geography of these areas in detail. But, beginning with Babylonia and Egypt, I should like to put the causes which seem to me to have promoted fixation quite briefly. Among them we must certainly include the primitive natural resources, scanty though these doubtless were. The birds of the valley marshes, the relatively small number of mammals, the fish of the rivers, must have supplied a certain amount of the animal food. The date palm, in the Tigris-Euphrates areas at least, would, even in its wild state, doubtless yield a fruit of some value in the very early days.

But as an important factor in the development of cultivation, I would lay especial stress upon the presence of what the botanists call the "open" plant formation. Native trees, as we know, are very few, the date palm, one of the most characteristic, being strictly limited in distribution by its need for water at the roots. For the greater part of the year the ground between the scattered trees is naturally either devoid of vegetation, or is represented only by a few desert plants. But after the periodic flooding by the rivers, an abundant growth of vegetation springs up. The plants may be annuals, the seeds of which ripen as the ground dries, and lie dormant till moisture comes again; or they may be bulbous and tuberous forms, having but a short period of vegetative activity, but possessing underground stems capable of withstanding prolonged drought. The result is that man did not require to clear land for crops; Nature periodically cleared it for him. He had but to make the fairly obvious deduction that water alone was necessary for the apparently barren soil to blossom like the rose; from all the choice of plants which the flooded ground offered, he had to pick out those of some use to him, and learn to suppress the rest. As has often been pointed out, he had no need to trouble greatly about renewing the fertility of his lands, for the flood-water did this for him.

So soon as he had learnt the initial lessons of cultivation, he was tied to the area normally flooded at certain seasons, or to which he could lead the flood-water. He intercalated his crops along one of Nature's lines of weakness, in a transitional area which passed periodically from one climatic zone to another, being, according to the seasons, either a desert or fertile.

The bordering desert ensured isolation, and, continuing the island metaphor, we may say that it represented the sea. Its effect was to throw the whole energy of the community towards the centre, for the periphery formed an area in which the characteristic mode of life could not be practised. Similarly, it gave protection, for it is unsuited to any save a highly specialised culture, which must have been of relatively late origin. So far as it formed the boundaries of the incipient state, therefore, the desert constituted a barrier preventing the ingress of potential foes. In neither case, of course, was the desert rim complete, and the conditions upstream varied in the two areas, and were, as has often been pointed out, from the point of view of safety, on the whole less favourable in the case of Babylonia than in that of Egypt.

As to the third point, it is, I think, easy to show that while the isolation of the areas was markedly conducive to the rise of civilisation and to its growth up to a certain point, in the long run it became a danger. First, the contrast between the belt which could be watered and that to which, with the means available, water could not be carried, was exceedingly sharp. There was little possibility of a gradual spread into areas becoming slowly but progressively different, where new aptitudes could be acquired, new experience gained, and new forms of wealth stored. Specialisation was high within the favoured tract, but the limits set by Nature could not be passed.

Again, as has often been noted, the conditions led necessarily to a centralised and imperialistic form of social organisation. If there was a sharp line of demarcation between the areas which could and could not be watered, there were great possibilities in the direction of extending by artificial means the belt over which the flood-water spread. This involved the gradual growth of an elaborate irrigation system, and for the maintenance of this a centralised power was essential. This brought with it, as a correlated advantage, the possibility of organised defence when developing neighbouring communities attempted to encroach. But if the attack was made with sufficiently powerful forces, the centralisation became a menace. An attacking foe able to destroy or damage seriously the irrigation system could cut off at its source the basis of prosperity, and render reconstruction on the old scale almost impossible. In other words, the community became adapted to artificial conditions created by itself; if and when those conditions were destroyed, the survival of the old culture became impossible.

Turn next to the Mediterranean region, that is, to the area in which the typical Mediterranean climate prevails. In so far as the native plants are concerned, this area shows certain broad general resemblances to the river-valleys, with some striking differences. Thus the characteristic plant formation is alternately open and closed; closed during the cooler season of the year when the winter rains cause a brief but intense growth of annuals and bulbous or tuberous plants, open during the drought of summer when the trees and shrubs stand apart from each other with bare earth between. But the contrast is due, as indicated, to the rainfall conditions, not to flooding. There is thus no natural renewal of fertility, and plants which require much water can only thrive in the cooler season, so that growth is less intense than in either the Nile or the Euphrates-Tigris valley.

On the other hand, because of the climatic conditions, trees and shrubs, alike as regards individuals and species, are far more numerously represented in the Mediterranean region. Here, however, we come to a very curious fact, which, though it is familiar enough, does not seem to have been considered in all its bearings. This is that, despite the (relative) wealth of native species of shrubs and trees, those which are cultivated seem to have been for the most part introduced. This is apparently true even of the supremely important olive. The tree occurs in the fossil state, and the olivaster of the maquis is believed by many to be truly wild, not feral. Yet it would appear almost certain that the *cultivated* olive was introduced, into Europe at least. The same thing is true of great numbers of other species, and of all the fruit-bearing trees now grown in the area there are few indeed which can be reasonably regarded as having originated there as cultivated forms. Now, the deduction that I would draw is that the Mediterranean area is one in which lessons first learnt elsewhere could be easily practised, but one rendered unsuited by the natural conditions for the taking of the first steps.

Man was doubtless first attracted to the area, as in the case of the river-valleys, by the natural resources, small though these must have been, even with the addition of the sea fisheries. He became fixed to it when he learnt that the hill spurs gave safe sites for settlements, while affording easy access to the slopes on which he could carry on his special form of intensive cultivation. That form, as already suggested, was a derived and not an original one. He replaced the native trees and shrubs by useful cultivated varieties or species, which had, certainly for the most part, originated elsewhere. He intercalated short-lived annuals like corn crops and beans along the line of weakness indicated by the periodic opening and closing of the natural vegetation. But one of his great difficulties was always that the absence of much level land and the climatic conditions rendered the growth of such crops relatively difficult, much more difficult than in the river-valleys.

If we think of the early settlements as showing a general resemblance to the Berber villages of the Algerian Atlas to-day, we realise that they were more or less isolated from one another, so that the social polity was of a wholly different type from that existing either in Babylonia or in early Egypt. But, and this seems to me important, although the natural conditions—especially the fact that fertility was limited to certain areas—made a measure of isolation inevitable, yet the sea gave a possibility of free movement in all directions which was absent in the river-valleys. Thus oversea, if not overland, spreading could take place, and the changes in the geographical conditions as the sea is traversed westward are relatively small, not outside the limits of adaptation. Thus we have the spread of the higher forms of Mediterranean culture from the eastern end of the sea towards the west, with the founding of new settlements of generally similar type to the old. This possibility of free movement brought with it a wider range of adaptability, a constant willingness to profit by new experiences, which has proved of enormous value to the world at large.

But with all its advantages the Mediterranean area, as already stated, had the great disadvantage that bread-stuffs were difficult to produce in quantity. Two methods of getting over that difficulty could be and were practised. For example, the ancient Greeks, having, it would appear, learnt the lesson from the Phœnicians, dared, in course of time, to descend from their hill-spurs to the sea-coast, in order to supplement the scanty resources of their limited lands by sea-trading. After a long interval the medieval cities, especially of Italy, did the same thing on a greater scale and with the advantage of a wider market. Between the two periods Rome tried the other possible method, that of holding in subjection the areas, outside that of the characteristic climate, which were corn-producing. Her failure was, at least in part, due to geographical causes. The great advantage of the method of sea-trading was the increase in the power of adaptation which it brought, as a result of the continual peaceful contact with other lands and other peoples. The decay of the splendid medieval cities of Italy came when the Mediterranean ceased to be a great highway of commerce, and the vivifying breezes from the outside world which had swept through it took another course—once again, therefore, a civilisation based upon a delicate adjustment to a particular set of conditions fell when those conditions changed.

Let us turn next to the third great area where, comparatively late, a complex civilisation grew up, that of the forest belt of Central and Western Europe. Here the conditions appear relatively so unfavourable that man could scarcely have solved the problem of fixing himself permanently to particular areas, and adapting himself to them, were it not for the help of the experience gained elsewhere. The great agent in transmitting that experience was, of course, first the Roman Empire, and then the Church which was the direct heir of the empire.

The essential difficulty here was that the characteristic plant formation was the closed temperate forest. At first sight there appears to be within it no line of weakness along which cultivated plants can be intercalated, and the establishment of cultivation seems to depend upon the complete destruction of the natural vegetation, involving the slow and peculiarly laborious clearing of the forest. Had the temperate forest been in point of fact as continuous as we are apt to assume, the problem would have been so difficult that the hunter's life in the forest might have lasted much longer than it did. We know, of course, that there were always "islands" in the sea of green, and of these the most important, from the point of view of the development of cultivation, were the loess areas and the lower uplands, especially those over chalk. We have, therefore, as our starting-point in this case scattered settlements in the woods—not compact ones like those of the Mediterranean region. As to the next stage, the surrounding wood must be regarded from two points of view. Initially it formed a protection, the protective influence being strongest where the ground was ill-drained, owing to the dense thickets which covered the marshy ground. But, in contrast to both the types of region already considered, given the necessary tools for the clearing of the land, the particular type of cultivation could be extended almost indefinitely on the level, while leaving the woods on the rising ground to supply the necessary fuel, building material, and pannage for the swine. This was a great advantage, but it meant that the necessary protection was soon lost.

In North-Western Europe that protective influence was peculiarly necessary for one geographical reason, as it was on the eastern margin of the continent for another. It was necessary in the west especially, because the sea-coasts, owing to the local wealth of fish, early attracted population. But in many regions those coasts, exposed to the oceanic type of climate in its most pronounced form, were unsuited to cultivation. At the same time, on account of their sheltered inlets, parts of those coasts were well fitted to breed a seafaring folk. Unable, or able only to a very small degree, to supplement their natural resources by cultivation, having at the same time command of the sea, those seafarers tended constantly to raid the painfully cleared and cultivated lands of their more fortunately situated neighbours, who, time and again, found their encircling woods a protection. We must suppose, therefore, that the tendency to clear more and more land would be checked by this need for the shelter of the woods.

But it seems to me that we may regard the growth of feudalism, from one point of view, as an adaptive device by which the growing agricultural settlements obtained, at a price, the necessary protection. Feudalism, in the form, for example, in which it grew up in England before the coming of the Normans, was a means of ensuring the existence of a kind of organisation which permitted clearing of forest land to go on indefinitely, while diminishing the risk of perpetual raiding.

It was also, more especially in Eastern Europe, something more, for it tended to fix the cultivator to the land. The tendency to wander may be said to be almost universal in the case of forest-dwellers carrying on primitive agriculture. Its wide distribution is due to the great difficulty of maintaining there the fertility of the land, more especially when exhausting crops, like the different kinds of grain and flax, are grown.

Feudalism helped in the solution of this problem by checking the natural tendency of the cultivator to abandon exhausted lands and move on to new ones. But even apart from this particular device, the problem of maintaining fertility had to be tackled early in the West, because the relief made the forest far less continuous and uniform than in the East. It must have been obvious quite early that it was not illimitable. Conditions were different in the forest region of the East, where the vast, almost uniform plains, the absence of well-marked relief, and the breadth of the continent made the forest a more permanent and unmanageable element than in Western Europe. Here, therefore, we find in suggestive combination two peculiar features. The first is that the wandering instinct, the instinct that brought the Slavs from their eastward forest home far into Central and Southern Europe, still persists. It is said to be quite well marked in parts of Russia, despite all the artificial checks which existed under the old regime. Part of the difficulty of the Slav problem also lies in the fact that the effect of the habit of small groups of wandering constantly from one wooded tract to another is written large on the ethnological map.

The second peculiar feature is that feudalism, and feudalism in a very harsh form, survived here far longer than in Western Europe, and in fact, if not in law, had scarcely disappeared when the war broke out. I would suggest that the great significance of this form of social policy here was that it helped to counteract the effects of the natural conditions, that it was fundamentally an artificial device for rendering the population stationary, and enabling it to adapt itself to the local relief and associated phenomena.

Now, whatever its value in earlier days, the present chaos in Eastern Europe shows clearly enough that ultimately it checked social evolution, and became a serious menace. It was fundamentally the erection of an artificial barrier round the rural community, and led to the apparent loss of the power of slow adaptation to changing conditions, alike on the part of the overlords and of the freed serfs.

But in the eastern chaos another factor has to be borne in mind. In the Old Russia, south of the forested area, and extending both into what is and was Rumania, lie the great treeless plains. Parts of these, as the nineteenth century showed, are extraordinarily fertile and well adapted for cereal production. But, from the point of view adopted here, they suffered from the enormous disadvantage that there is nothing in the natural conditions to fix their inhabitants to special areas, thus enabling them to acquire qualities fitting them for life there; nothing to give protection from constant inroads from Asia. Literally wastes for long centuries, these plains were for the most part ultimately incorporated in Imperial Russia, and deliberately colonised, often with colonists from a distance. The colonists were brought from areas of other characters, possessed traditions and aptitudes due to long experience of different geographical conditions, and were in the grip of a Government which had itself evolved under those conditions. There was thus no question of the possibility of the evolution of a type of culture bearing the imprint of the local conditions.

In consequence Russia to-day—as well as to some extent Rumania—is faced with a double problem. In both regions parts of the constituent lands are fitted for the mixed cultivation of the forest belt, and in them the old social policy has shown itself unfitted for modern conditions, and a new one has yet to be evolved. Other parts, again, have never developed even an imperfect social policy which was a response to their own local environment. Their apparent prosperity, till the outbreak of the war, was due to the fact that they were, economically though not politically, of the nature of colonies in relation to the industrialised West; they were, fundamentally speaking, the equivalents of Imperial Rome's corn-producing lands in North Africa and the Danubian plains. The chaos in Eastern Europe is thus having a reflex disturbing effect upon the West. The West has lost an important market, but that is perhaps in itself less important than the fact that over a large tract of European land man and his environment have been thrown out of gear, a catastrophic condition which inevitably disturbs equilibrium elsewhere. Just as in the later days of the Roman Empire disturbances in the marginal corn-producing lands shook and ultimately overthrew the centre, so are the centres of Western European civilisation to-day trembling under the impact of shocks emanating from the East. We can well understand, therefore, how it is that there are those who believe that the focus of civilisation is destined to undergo another shift, and that the day of the predominance of North-Western Europe is drawing to a close.

The subject is not one which can be discussed here. But if I may sum up briefly the points I have been trying to make, I would say that the human geographer should have before him a twofold purpose. First, he should strive to show that the deductions which the biologists have slowly and painfully laid down in the course of the last sixty years apply, though with an essential difference—which requires careful definition—to the life of man. Secondly, he should use his precise knowledge of the surface of the earth to work out detailed applications of those deductions. In other words, human geography is the biology of man, and, on account of man's vast power of modifying his environment, necessitates a fuller knowledge of that environment than can be required of the biologist in the narrower sense. Investigations along these lines would, I think, promote greatly the interests of geography as a whole, both by making clear to the general public its value and in justifying that intensive study of the surface relief and the associated phenomena which must always remain its basis.

Educational and School Science.[1]

By Sir RICHARD GREGORY.

THE Educational Science Section of the British Association, which attains its majority this year, was established to consolidate the claims staked out by workers in different educational provinces, and promote common interest in their development as a whole. As Prof. H. E. Armstrong explained at the opening meeting, it was proposed to devote attention to education in all its branches with the object of introducing scientific conceptions into every sphere of educational activity; that is, conceptions which imply such exact and profitable treatment of a subject as should come from full knowledge. Educational science signifies, however, much more than methods of teaching or the theory of the curriculum. It involves conditions of physical, mental, and moral health, with their manifold types and variations, and the determination of the most appropriate, and therefore most effective, factors of growth at every stage of development. In its present stage educational science must be largely empirical, but in this respect it does not differ from meteorology, for example; and the laws which govern the perpetually varying contents and conditions of a child's mind are not much less precisely known or applied than those by which atmospheric changes are determined.

Education may, therefore, be defined as the deliberate adjustment of a growing human being to its environment; and the scope and character of the subjects of instruction should be determined by this biological principle. What is best for one race or epoch need not be most appropriate for another, but always the aim should be to give the pupil as many points of contact with the world around him as may be profitably developed during his school career. This does not mean, of course, that his vision is to be confined to contemporary necessities or his thoughts to provincial or even national fields. The resources available for his instruction and guidance comprise the wisdom and experience of the past as well as the power of the present, and in their extensive and varied character they now provide teachers with educational opportunities richer and fuller than those of any other period of the world's history. Literature and art form noble domains of the heritage into which the child of to-day is born, but they were mostly planted long ago, and their shapes have not been altered much in modern times. Science has, however, transformed the whole landscape entrusted to it, and the realm of its productivity is continually extending. It is a kingdom potent with possibilities for good or evil—an inheritance which cannot be renounced—and to let any of our children grow up unfamiliar with their entailed possession is to neglect an obvious duty.

The essential mission of school science is thus to prepare pupils for civilised citizenship by revealing to them something of the beauty and the power of the world in which they live, as well as introducing them to the methods by which the boundaries of natural knowledge have been extended and Nature herself is being made subservient to her insurgent son. We live in a different world to-day from that of medieval times, when the *trivium* of grammar, logic, and rhetoric, with the *quadrivium* of arithmetic, geometry, music and astronomy, comprised the subjects of a complete education in the sciences as well as in letters—different indeed from what it was only a century ago. The influence of science is now all-pervading, and is manifest in all aspects of human activity, intellectual and material. Acquaintance with scientific ideas and methods and applications is forced upon every one by existing circumstances of civilised life with its facilities for rapid transport by air, land, or sea, ready communication by telephone or telegraph, and other means by which space and time have been brought under control and man has assumed the mastership of his physical and social destiny. Science permeates the atmosphere in which we live, and those who cannot breathe it are not in biological adjustment with their environment—are not adapted to survive in the modern struggle for existence.

School instruction in science is not, therefore, intended to prepare for vocations, but to equip pupils for life as it is and as it soon may be. It is as essential for intelligent general reading as it is for everyday practical needs; no education can be complete or liberal without some knowledge of its aims, methods, and results, and no pupil in primary or secondary schools should be deprived of the stimulating lessons it affords. In such schools, however, the science to be taught should be science for all, and not for embryonic engineers, chemists, or even biologists; it should be science as part of a general education—unspecialised,

[1] From the presidential address delivered to Section L (Educational Science) of the British Association at Hull on Sept. 7.

therefore, and without reference to prospective occupation or profession, or direct connexion with possible university courses to follow. Less than 3 per cent. of the pupils from our State-aided secondary schools proceed to universities, yet most of the science courses in these schools are based upon syllabuses of the type of university entrance examinations—syllabuses of sections of physics or chemistry, botany, zoology, and so forth—suitable enough as preliminary studies of a professional type to be extended later, but in no sense representing in scope or substance what should be placed before young and receptive minds as the scientific portion of their general education. Such teaching excuses the attitude of many modern Gallios among schoolboys caring "for none of those things." The needs of the many are sacrificed to the interests of the few, with the result that much of the instruction is inept and futile whether judged by standards of enlightenment or of stimulus. Exceptional pupils may profit by it, but to others, and particularly to teachers of literary subjects in the school curriculum, it often appears trivial or sordidly practical, and is usually spiritless—a means by which man may gain the whole world, but will lose his soul in the process.

This impression is not altogether unjust, and the teaching of recent years has tended to accentuate it. The extent of school science is determined by what can be covered by personal observation and experiment—a principle sound enough in itself for training in scientific method, but altogether unsuitable to define the boundaries of science in general education. Yet it is so used. Every science examination qualifying for the First School Certificate, which now represents subjects normally studied up to about sixteen years of age, is mainly a test of practical acquaintance with facts and principles encountered in particular limited fields, but not a single one affords recognition of a broad and ample course of instruction in science such as is required in addition to laboratory work. I have not the slightest intention or desire to suggest that practical work can be dispensed with in the teaching of any scientific subject, but I do urge that it becomes a fetish when it controls the range of view of the realm of natural knowledge capable of being opened for the best educational ends during school life.

It is now generally recognised by educationists that up to the age of about sixteen years there should be no specialisation in school studies. The First School Examination was organised with this end in view, and seven examining bodies have been approved by the Board of Education to test the results of instruction given in (1) English subjects, (2) languages, (3) mathematics and science, which constitute the three main groups in which candidates are expected to show a reasonable amount of attainment. The number of candidates who presented themselves at examinations of the standard of First School Certificates last year was about 42,000; and of this number, 12,500 took papers in sections of physics, 13,000 in chemistry, 11,400 in botany, 5000 physics and chemistry combined under experimental science, 113 natural history of animals, 31 geology, and 3 zoology.

These numbers may be taken as a fair representation of the science subjects studied in most of our secondary schools, and they suggest that general scientific teaching is almost non-existent. Botany is a common subject in girls' schools, but the instruction in science for boys is limited to parts of physics and chemistry. The former subject is usually divided into mechanics and hydrostatics; heat; sound and light; and electricity and magnetism; and candidates are expected to reach a reasonable standard in two of these sections. They may, therefore, and often do, leave school when their only introduction to science is that represented by the study of mechanics and heat, and without the slightest knowledge of even such a common instrument as an electric bell, while the ever-changing earth around them, and the place of man in it, remain as pages of an unopened book. They ask for bread, and are given a stone. General science covering a wide field is practically unknown as a school subject, and even general physics rarely finds a place in the curriculum because questions set in examinations are, to quote from the Cambridge Locals Regulations, "principally such as will test the candidate's knowledge of the subject as gained from a course of experimental instruction."

One or two examining bodies have introduced general science syllabuses covering the rudiments of physics and chemistry as well as of plant and animal life, but even in these cases most of the subjects must be studied experimentally, and no place is found for any other means of acquiring knowledge. The result is that few schools find it worth while from the point of view of examination successes to attempt to cover such schemes of work. Moreover, no clear principle can be discerned by which the syllabuses are constructed. General science should be more than an amorphous collection of topics from physics and chemistry, with a little natural history thrown in as a sop to biologists. It should provide for good reading as well as for educational observation and experiment; should be humanistic as well as scientific. The subject which above all others has this double aspect is geography; so truly, indeed, is this the case that in the First School Examinations it may be offered in either the English or the Science group. A school course which would cover all the science required for the study of geography conceived as a branch of knowledge concerned with the natural environment of man and the inter-relations between him and those circumstances would not only be educational in the broadest sense, but would also be the best groundwork for effective teaching of geography, history, and other humanistic studies. It would make science a natural part of a vertebrate educational course instead of specialised and exclusive as it tends to be at present.

It cannot be reasonably suggested that the order in which the usual sections of physics are prescribed has any relation to mental growth, or that the topics selected from them are such as appeal to early interests. Few pupils of their own volition wish to determine specific gravities, investigate the laws of motion, calculate specific and latent heats, and so on, at the stage of instruction in science at which these matters are usually studied, and from the point of view of educational value most of them would be more profitably employed in becoming acquainted with as wide a range as possible of common phenomena and everyday things—all considered as qualities to stimulate attention instead of quantities to be measured with an accuracy for which the need cannot be seen and by methods which easily become wearisome. The "Investigators" appointed by the Board of Education in 1918 to report upon the papers set in examinations for the First School Certificate were right when they expressed their opinion "that the early teaching of physics has suffered from too great insistence on more or less exact quantitative work, to the neglect of qualitative or very roughly quantitative experiments illustrating fundamental notions." By the prevailing obsession in regard to quantitative work the pupil is made the slave of the machine, and appliances become encumbrances to the development of the human spirit.

When instruction in science was first introduced into schools its character was determined by insight and conviction rather than by mental needs or interests; so later, when practical work came to be regarded as an essential part of such instruction, its nature and scope represented what certain authorities believed pupils should do, instead of what they were capable of doing with intelligence and purpose. Practical chemistry became drill in the test-tubing operations of qualitative analysis, and the result was so unsatisfactory from the points of view of both science and education that when Prof. Armstrong put forward a scheme of instruction devised by him, in which intelligent experimentation took the place of routine exercises, acknowledgment of its superior educational value could not be withheld, and for thirty years its principles have influenced the greater part of the science teaching in our schools.

Prof. Armstrong's particular contribution to educational science consisted in the production of detailed schemes of work in which these principles were put into practice. Ideas are relatively cheap, and it needs a master mind to make a coherent story or useful structure from them. This was done in the courses in chemistry outlined in Reports presented to the British Association in 1889 and 1890, and the effect was a complete change in the methods of teaching that subject. "The great mistake," said Prof. Armstrong, "that has been made hitherto is that of attempting to teach the elements of this or that special branch of science; what we should seek to do is to impart the elements of scientific method and inculcate wisdom, so choosing the material studied as to develop an intelligent appreciation of what is going on in the world." One feature of heuristic instruction emphasised by its modern advocate, but often neglected, is that which it presents to the teaching of English. Accounts of experiments had to be written out in literary form describing the purpose of the inquiry and the bearing of the results upon the questions raised, and wide reading of original works was encouraged. A few years ago English composition was regarded as a thing apart from written work in science, but this should not be so, and most teachers would now agree with the view expressed by Sir J. J. Thomson's Committee on the Position of Natural Science in the Educational System of Great Britain that "all through the science course the greatest care should be taken to insist on the accurate use of the English language, and the longer the time given to science the greater becomes the responsibility of the teacher in this matter. . . . The conventional jargon of laboratories, which is far too common in much that is written on pure and applied science, is quite out of place in schools."

When heuristic methods are followed in the spirit in which they were conceived, namely, that of arousing interest in common occurrences, and leading pupils to follow clues as to their cause, as a detective unravels a mystery, there is no doubt as to their success. No one supposes that pupils must find out everything for themselves by practical inquiry, but they can be trained to bring intelligent thought upon simple facts and phenomena, and to devise experiments to test their own explanations of what they themselves have observed. It is impossible, however, to be true to heuristic methods in the teaching of science and at the same time pay addresses to a syllabus. A single question raised by a pupil may take a term or a year to arrive at a reasonable answer, and the time may be well spent in forming habits of independent thinking about evidence obtained at first-hand, but the work cannot also embrace a prescribed range of scientific topics. Yet under existing conditions, in which examinations are used to test attainments, this double duty has to be attempted by even the most enlightened and progressive teachers of school science. There can, indeed, be no profitable training in research methods in school laboratories under the shadow of examination syllabuses. Where there is freedom from such restraint, and individual pupils can be permitted to proceed at their own speeds in inquiries initiated on their own motives, success is assured, but in few schools are such conditions practicable; so that, in the main, strict adherence to the heuristic method is a policy of perfection which may be aimed at but is rarely reached.

A necessary condition of the research method of teaching science is that the pupils themselves must consider the problems presented to them as worth solving, and not merely laboratory exercises. Moreover, the inquiries undertaken must be such as can lead to clear conclusions when the experimental work is accurately performed. It may be doubted whether the rusting of iron or the study of germination of beans and the growth of seedlings fulfils the first of these conditions, and the common adoption of these subjects of inquiry is due to custom and convenience rather than to recognition of what most pupils consider to be worth their efforts. It needed a Priestley and a Lavoisier to proceed from the rusting of iron to the composition of air and water, and even such an acute investigator as Galileo, though well aware that air has weight, did not understand how this fact explained the working of the common suction pump.

The mission of school science should not, indeed, be only to provide training in scientific method—valuable as this is to every one. Such training does cultivate painstaking and observant habits, and encourages independent and intelligent reasoning, but it cannot be held in these days that any one subject may be used for the general nourishment of faculties which are thereby rendered more capable of assimilating other subjects. Modern psychology, as well as everyday experience, has disposed of this belief. If the doctrine of transfer of power were psychologically sound, then as good a case could be made out for the classical languages as for science, because they also may be taught so as to develop the power of solving problems and of acquiring knowledge at the same time. When, therefore, advocates of particular courses of instruction state that they do not pretend to teach science, but are concerned solely with method, they show unwise indifference to what is known about educational values. Locke's disciplinary theory—that the process of learning trains faculties for use in any fields, and that the nature of the subject is of little consequence—can no longer be entertained. It has now to be acknowledged that information obtained in the years of school life is as important as the process of obtaining it; that, in other words, subject matter as well as the doctrine of formal discipline must be taken into consideration in designing courses of scientific instruction which will conform to the best educational principles.

So long ago as 1867 the distinction between subject and method was clearly stated by a Committee of the British Association, which included among its members Prof. Huxley, Prof. Tyndall, and Canon Wilson. It was pointed out that general literary acquaintance with scientific things in actual life, and knowledge relating to common facts and phenomena of Nature, were as desirable as the habits of mind aimed at in scientific training through "experimental physics, elementary chemistry, and botany." The subjects which the Committee recommended for scientific information, as distinguished from training, comprehended "a general description of the solar system; of the form and physical geography of the earth, and such natural phenomena as tides, currents, winds, and the causes that influence climate; of the broad facts of geology; of elementary natural history with especial reference to the useful plants and animals; and of the rudiments of physiology." If we add to this outline a few suitable topics illustrating applications of science to everyday life, we have a course of instruction much more suitable for all pupils as a part of their general education than what is now commonly followed in secondary schools. It will be a course which will excite wonder and stimulate the imagination, will promote active interest in the beauty and order of Nature, and the extension of the Kingdom of Man, and provide guidance in the laws of healthy life.

The purpose of this kind of instruction is, of course, altogether different from that of practical experiment in the laboratory. One of the functions is to provide pupils with a knowledge of the nature of everyday phenomena and applications of science, and of the meaning of scientific words in common use. Instead of aiming at creating appreciation of scientific method by an intensive study of a narrow field, a wide range of subjects should be presented in order to give extensive views which cannot possibly be obtained through experimental work alone. The object is indeed almost as much literary as scientific, and the early lessons necessary for its attainment ought to be within the capacity of every qualified teacher of English. Without acquaintance with the common vocabulary of natural science a large and increasing body of current literature is unintelligible, and there are classical scientific works which are just as worthy of study in both style and substance as many of the English texts prescribed for use in schools. We all now accept the view that science students should be taught to express themselves in good English, but little is heard of the equal necessity for students of the English language to possess even an elementary knowledge of the ideas and terminology of everyday science, which are vital elements in the modern world, and it is the business of literature to present and interpret them.

It may be urged that knowledge obtained through descriptive lessons has no scientific reality unless it is derived from first-hand experience, and this is no doubt right in one sense; yet it is well to remember that science, like art, is long, while school life is short, and that though practical familiarity with scientific things must be limited, much pleasure and profit can be derived from becoming acquainted with what others have seen or thought. It is true that we learn from personal experience, but a wise man learns also from the experience of others, and one purpose of a descriptive science course should be to cultivate this capacity of understanding what others have described. As in art, or in music, or in literature, the intention of school teaching should be mainly to promote appreciation of what is best in them rather than to train artists, musicians, or men of letters, so in science the most appropriate instruction for a class as an entity must be that which expands the vision and creates a spirit of reverence for Nature and the power of man, and not that which aims solely at training scientific investigators.

The Royal Botanic Gardens, Kew.

THE area occupied by the Royal Botanic Gardens of Kew, as we know them to-day, is mainly the result of the union of two demesnes, both of them famous in a horticultural sense long before they came to be associated in particular with the science of botany. These two demesnes were, first, the grounds originally attached to a house in the Old Deer Park of Richmond known as Ormonde Lodge, Richmond Lodge, and finally, when it came to be occupied by George II. (then Prince of Wales) about 1721, as Richmond Palace; secondly, the grounds belonging to Kew House or White House, a dwelling that stood near the present Kew Palace, and which, after being occupied by the families of Bennett, Capel, and Molyneux, came into the possession of Frederick, Prince of Wales, in 1730. On the death of George II. in 1760, both properties came under the ownership of his grandson, George III. At that time they were divided by an ancient bridle-path known as "Love Lane," which ran from Richmond Green to a horse-ferry over the Thames at Brentford. George III. obtained Parliamentary sanction to close Love Lane, with the obliteration of which, in 1802, Richmond Gardens and Kew Gardens became the larger Kew Gardens we know at the present time.

In the aero-photograph here reproduced we are looking almost due north, and most of the area shown belongs to the Kew Gardens of the eighteenth century. It is bounded on the east by the Kew Road, some of the villas of which are shown towards the top right-hand corner of the picture. It is on this area that all the plant-houses, museums, and other buildings are situated. Richmond Gardens were bounded on the west by the Thames, and part of their site is the thickly wooded area shown towards the top left-hand corner of the photograph.

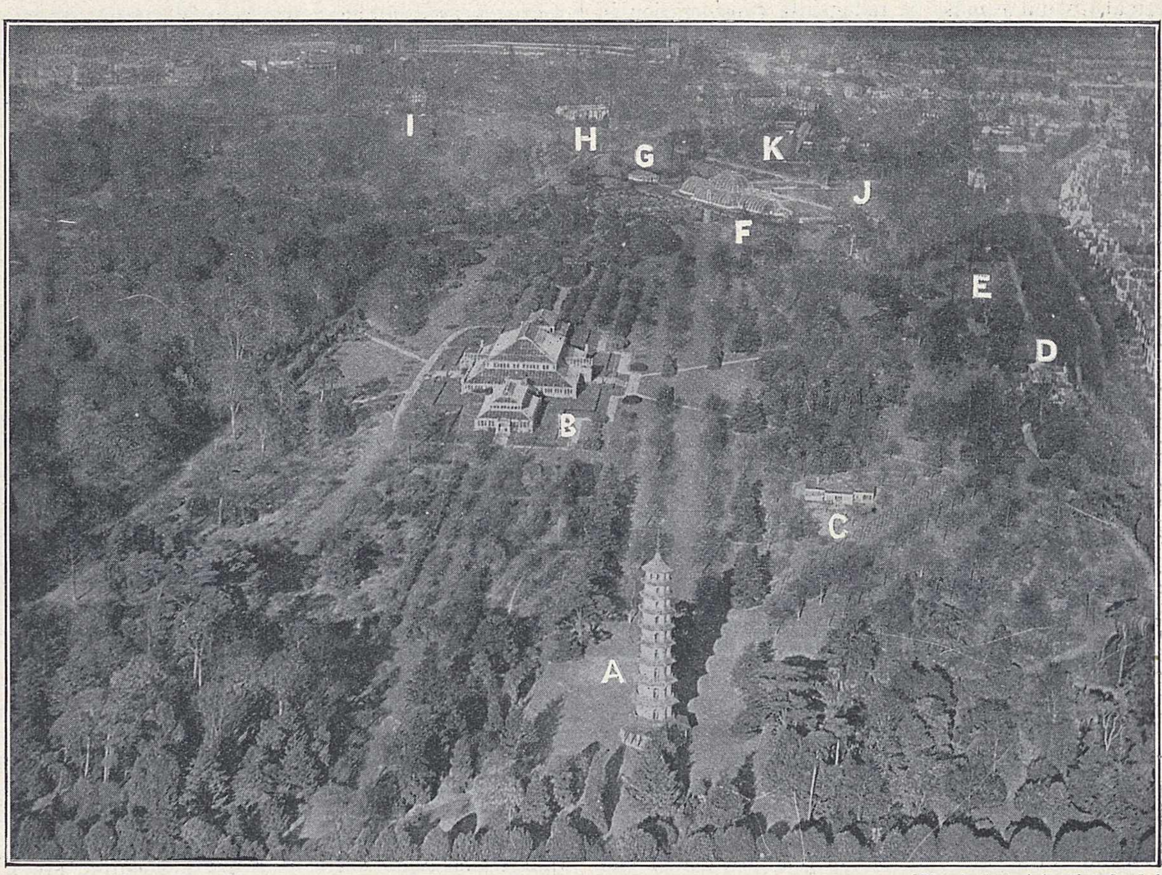
Under Queen Caroline, consort of George II., Richmond Gardens became famous for the costly and elaborate operations she carried out there. She built Merlin's Cave, the Hermitage, and various temples and other structures, all of which disappeared soon after George III. came to the throne. Even Richmond Lodge itself was razed to the ground in 1772.

The old Kew Gardens had a longer and more interesting history. John Evelyn made several references to them in his Diary. In August 1678 he records that the gardens had the "choicest fruit of any in England," and under the date February 24, 1688, he wrote, "we went to Kew to visit Sir Henry Capel's whose orangery and myrtetum are most perfectly kept." From the accounts of Evelyn and others it appears certain that, even 250 years ago, Kew was one of the best gardens in England.

Sir Henry Capel died in 1696, and the property descended to his grand-niece, the wife of Samuel Molyneux. Molyneux had a taste for astronomy and converted part of Kew House into an observatory. It was here that his friend Dr. Bradley, afterwards Astronomer Royal, made his two important discoveries, the aberration of light and the nutation of the earth's axis. Kew House was pulled down in 1802, but the site of the observatory and Bradley's discoveries is now marked by a sun-dial.

The foundation of the Botanic Garden at Kew has to be credited to Augusta, Princess of Wales and mother of George III. Under the superintendence of Lord Bute, about nine acres were laid out in 1760, the portion devoted to herbaceous plants, then called the Physic Garden, being arranged on the then newly devised Linnaean System. Willam Aiton, a pupil of Philip Miller of Chelsea and afterwards the author of the "Hortus Kewensis," was appointed head gardener, and Sir William Chambers, the architect of Somerset House, erected a number of temples and other buildings, of which several, including the Pagoda, are still conspicuous features of the place.

Between 1760 and 1841 Kew had a period of brilliant success and one of decadence. Princess Augusta died in 1772 and George III. substituted Sir Joseph Banks in place of Lord Bute as unofficial director of the Botanic Garden. Banks was largely interested in the fortunes of the garden until his death in 1820, and his association with it no doubt was the chief agency that ultimately gave it the premier position among



[*Photo by Central Aerophoto Co., Ltd.*

THE ROYAL BOTANIC GARDENS, KEW.

A=Pagoda. B=Temperate House. C=Refreshment Pavilion. D=North Gallery. E=Flagstaff. F=Palm House. G=Water-Lily House. H=No. III. Museum (Orangery). I=Kew Palace. J=Pond. K=Cactus House.

botanic gardens of the time. Plant collectors were despatched to various countries, the first being Francis Masson, who went to South Africa in 1772.

After the death of George III. as well as that of Banks in 1820, the gardens gradually declined in efficiency and repute, until at the accession of Queen Victoria there was a serious danger of their disappearance altogether as a botanic establishment. However, a committee of inquiry, headed by John Lindley, reported strongly in favour of their continuance and further development, and in 1840 their control was vested in the Commissioners of Woods and Forests. In 1841, Sir William Hooker was appointed director, and thus was inaugurated the second great period in the history of Kew.

During the last eighty years the area devoted to botany and horticulture has increased from about 15 acres to 288 acres. Its work as the botanical centre of the British Empire and for the distribution of economic plants to all our colonies and possessions is well known. To the public generally it is, of course, best known as a popular resort. Nor must its place as a training school in horticulture be forgotten, especially for curators of Colonial and Indian Botanic Gardens and superintendents of public parks at home. No better testimony of its value to the Empire can be adduced than that of Joseph Chamberlain, then Colonial Secretary, in the House of Commons on August 2, 1898: "I do not think it is too much to say that at the present time there are several of our important colonies which owe whatever prosperity they possess to the knowledge and experience of, and the assistance given by, the authorities at Kew."

In pure botany its chief work has been the preparation and publication of Floras of British possessions—a botanical survey of the Empire. Bentham and Hooker prepared their "Genera Plantarum" at Kew, and the monumental "Index Kewensis" was compiled there. The Herbarium contains some 2,500,000 specimens and the library upwards of 24,000 volumes.

Turning to the more conspicuous objects in the accompanying illustration, the one that catches the eye first is the Pagoda (A). This was erected by Sir William Chambers in 1761–2; it has ten storeys and is 163 feet high. From its summit the Crystal Palace is usually visible and, with a favourable atmosphere, Windsor Castle. During the coal strike in the spring of last year all the more lofty buildings as far as St. Paul's could be seen.

The Temperate House (B) is a structure of three main compartments, the large central one, built in 1862, being devoted largely to the cultivation of Australian and New Zealand trees and shrubs, the smaller ones, built 1897–1899, to Himalayan and subtropical ones. The North Gallery (D) contains 848 paintings of flowers and tropical and subtropical vegetation by the late Marianne North; both the paintings and the buildings were presented by her to Kew in 1882. The Flagstaff (E), which appears merely as a dark streak in the illustration, was presented by British Columbia, and is 214 feet high, 2 feet 9 inches in diameter at the base, 1 foot in diameter at the summit; at the time of its erection in October 1919 it weighed 18 tons.

The Palm House (F), where tropical plants, such as palms, cycads, pandanads, bamboos, and bananas, are grown, is an iron structure built 1844–1848. It is 362 feet long and 66 feet high in the centre. The Orangery (H) is one of Chambers's buildings and was erected in 1761. The orange trees originally housed there were transferred to Kensington Palace in 1841, soon after Kew became public property. It is now known as Museum III. and contains exhibits of exotic timber and miscellaneous objects.

Kew Palace (I), once known as the Dutch House, is a red brick, Jacobean dwelling, built by Samuel Fortrey in 1631. By his grandson it was sold to Sir Richard Levett, who was Lord Mayor of London in 1700, and in 1781 it was purchased from the Levetts by George III., who used it as a dwelling for himself and his large family when the Court was at Kew. His sons, the Dukes of Clarence and of Kent, were married in one of the rooms, and his wife, Queen Charlotte, died there November 17, 1818. It is now open to the public who visit the Gardens, but is not attached in any scientific sense to the establishment, containing only mementoes of the Royal Family.

Obituary.

Dr. R. H. Codrington.

In the fulness of years, at the age of ninety-two, Dr. R. H. Codrington, the apostle of Melanesia, has passed away. After a distinguished Oxford career he became Fellow of Wadham; soon after, he joined Bishop Patteson and afterwards lived with Bishop Selwyn at Norfolk Island. After thirty-two years' service in the Melanesian mission he returned to England and became vicar of Wadhurst and Prebendary of Chichester. A friend who knew him well describes him as "the soundest of scholars, kindliest of teachers, most practical of saints, most genial and tolerant of friends." He will be remembered as the first and greatest ethnologist and linguist who studied the people of Melanesia. His fame rests on two great books—"The Melanesian Languages," and "The Melanesians, their Anthropology and Folk-lore," published by the Oxford Press in 1855–1891. The former laid the foundation of the scientific knowledge of the speech of that region; the second is invaluable to the anthropologist as giving the first and fullest account of religious beliefs. Dr. Codrington was also the discoverer of the principle of Mana, which has played a leading part in the exploration of savage religion since he made it known to the world.

The *Chemiker Zeitung* for September 5 announces the death on August 7 of Prof. Emilio Noelting, for many years Director of the Chemical School at Mülhausen. Prof. Noelting was an authority on dye-stuffs; he was born on June 8, 1851, at Porta Plata, San Domingo, and after study at Zürich he took up his position at Mülhausen in 1880. In the issue for September 9 of the same journal the death is announced of Prof. E. Bergmann, director of the Chemisch-Technische Reichsanstalt, Berlin.

Current Topics and Events.

STAGNATION of trade in the year 1921 is responsible for a situation in the American dyestuff industry resembling, in many respects, that which prevailed in this country. Firms engaged in the manufacture of coal-tar derivatives numbered 201, of which 74 produced colouring-matters with an output of 39,000,000 lb., while the sales exceeded 47,000,000 lb. Thus the domestic consumption of that year was in part supplied from the large stocks carried over from the previous year's abnormally high production. Nevertheless, it is satisfactory to note that progress was made in the direction of a wider range, many dyes of greater complexity and more specialised application being produced and marketed for the first time in the United States; although such materials do not make substantial additions to the bulk of production, they are essential factors in the development of a flourishing domestic industry. Further encouragement follows from the circumstance that in the year 1914 the United States imported nearly 46,000,000 lb. of dyes and produced only 6,000,000 lb., almost entirely from German intermediates. There are still requirements which have to be met from foreign sources, however, 3,914,036 lb. being imported in 1921, principally from Germany (48 per cent.) and Switzerland (41 per cent.); while this quantity exceeds by 511,454 lb. the amount imported in 1920, the average price has fallen from 1·7 dollars for that year to 1·3 dollars for 1921. Simultaneously, the price of domestic dyes has fallen from an average of 1·08 dollars per lb. in 1920 to 83 cents in 1921. From an American standpoint, the most disturbing feature of the year under review is the diminution of exports, the value of which has fallen from 29,833,591 dollars in 1920 to 6,270,139 dollars in 1921; the total exports thus fell below those of the year 1917, when the first considerable expansion of the domestic dye-manufacturing industry from pre-war dimensions was noted.

SUBJECT to the sanction of Parliament, the Ministry of Agriculture is putting forward a further scheme for the drainage of agricultural land as a measure towards the relief of unemployment, especially in rural districts. It is estimated that last winter not less than 340,000 acres were relieved of flooding or water-logging, but a far greater area is still in need of drainage. The scheme is designed for the improvement of arterial drains and watercourses, and grants cannot be made in aid of such work as tile-draining or the cleansing of field ditches. The work must in all cases be completed by March 11, 1923, as no public money will be forthcoming after March 31 next. All schemes from Drainage Authorities must be submitted to the Ministry before December 1, and from County Agricultural Committees before December 16. As the main object to be achieved is to get unemployed men rapidly to work, the Ministry does not intend to let any unnecessary formalities stand in the way of schemes that can be put into operation promptly.

THE Journal of the Royal Society of Arts for August 4 contains the three Cantor Lectures recently delivered before the Society by Mr. C. Ainsworth Mitchell, on "Inks." It is sixty-five years since a communication was made to the Society on this subject—the previous one being a paper by Mr. Underwood in 1857. The lecturer traces the use of inks as far back as 2697 B.C., the date of an old Chinese manuscript in which is described the process of making Chinese ink from lamp-black and glue. Iron gall inks are known to have been used in this country as early as the ninth century A.D. The use of indigo in blue-black ink was introduced in this country in 1836 by Stephens. Aniline dyes were certainly used in inks more than forty years ago, but their presence in the inks in entries in old family Bibles put forward as proofs that claimants for old age pensions were seventy years old, has several times been fatal to the claim. Documents alleged to date from 1719 to 1792 in support of a claim to a baronetcy were proved to be written with ink containing aniline dyes, and therefore were certainly very much more recent. The manufacture, properties, sophistication, analysis, and legal aspects of the uses of inks of various kinds were discussed by the lecturer.

WE have already referred in these columns to the formation of L'Institut d'Optique and the publication of the *Revue d'Optique* in France. These measures have been taken in order that she may manufacture all the optical instruments she requires at home, instead of importing them. The July issue of the Bulletin of the Société d'Encouragement pour l'Industrie nationale contains a report on the first two years' work of the Institut. According to this report the services of the Institut are likely to be in great demand in the near future, and the accommodation at present provided must be extended. More instruments for the practical work of students are required, and time must be allowed in the three years' course for laboratory work. It is hoped that the publication of the lecture courses will reduce the time of attendance at lectures and thus provide the additional time required in the laboratory. The researches which the optical industry requests the Institut to carry out are increasing in number and importance and show that it meets a real need.

THE fourth centenary of the first circumnavigation of the world was celebrated at Guetaria, near San Sebastian, on September 7. Guetaria was the birthplace of Juan Sebastian del Cano, who succeeded to the command of Magellan's expedition after the leader was killed in the Philippines. He returned to Spain in the *Vittoria* on September 6, 1522. An international fleet of twenty-one ships assembled in the bay to take part in the centenary celebrations, at which Great Britain was represented by Rear-Admiral W. S. Nicholson in H.M.S. *Curaçoa*. A service in the old church was followed by a pageant depicting the scenes which took place on del Cano's return.

The King of Spain laid the foundation-stone of a monument to commemorate the voyage.

AFTER a journey of some 25,000 miles and an absence of almost a year, the *Quest* has returned with the members of the Shackleton-Rowett expedition, and entered Cawsand Bay, Plymouth, on September 15. According to the *Times*, valuable hydrographical work has been carried out in the Antarctic and around South Georgia and Elephant Island, and a large-scale map of Gough Island prepared. The highest point on the latter has been named Mount Rowett. In the Enderby Quadrant a point was reached farther south than the extreme latitudes reached by Biscoe and Bellinghausen, but severe pack-ice prevented the exploration of Enderby Land. Much meteorological data were collected. A new bird of the finch species and a new tree resembling an acacia were discovered on Gough Island. The *Quest* proceeded to Portsmouth, arriving on September 18, and Commander F. Wild received a telegram of welcome from the King; referring to the loss of Sir Ernest Shackleton, the King said: "Your record of achievement and the indomitable spirit displayed by all members of the expedition were in every way worthy of his great example."

PROF. L. BAIRSTOW will deliver a lecture to the Royal Aeronautical Society (at the Royal United Service Institution) at 5.30 on Thursday, October 5, on "The Work of S. P. Langley."

THE twenty-fifth annual Traill-Taylor Memorial Lecture of the Royal Photographic Society will be delivered by Dr. R. S. Clay on Tuesday, October 10, at 8 o'clock. The subject will be, "The Development of the Photographic Lens from the Historical Point of View."

THE following courses of free public Gresham Lectures will be delivered at 6 o'clock at Gresham College, Basinghall Street, E.C.: on October 17, 18, 19, 20—Astronomy, by A. R. Hinks; on October 24, 25, 26, 27—Physic, by Sir R. Armstrong-Jones; on November 14, 15, 16, 17—Geometry, by W. H. Wagstaff.

MR. E. LEONARD GILL has been appointed by the Civil Service Commissioners to fill the vacant Assistantship in the Natural History Department of the Royal Scottish Museum, Edinburgh. Mr. Gill has already had museum experience in Leicester and Manchester, and for almost twenty years has been in charge of the Hancock Museum at Newcastle-on-Tyne.

A CONFERENCE of representatives of some twenty of the smaller engineering societies has been arranged under the auspices of the Society of Engineers, to be held on September 29 at the Engineers' Club. The object of the meeting is to consider, and if thought advisable, to inaugurate an Association of British Engineering Societies. According to the draft constitution of the proposed Association, there would be no individual members, the constituent societies functioning as such; each society, however, would retain its independence. It is proposed to issue a journal or transactions in which all papers read before constituent societies would be printed and the expenses met by capitation grants from the societies concerned. Further particulars of the meeting and the proposals can be obtained from the Secretary of the Society of Engineers, 17 Victoria Street, S.W.1.

REFERRING to the obituary notice of Dr. Alexander Graham Bell in NATURE of August 12, p. 225, Mr. F. De Land, of the Hubbard Memorial Hall, Washington, D.C., informs us that the Boston newspapers of Monday, November 27, 1876, tell the story of transmitting speech on the previous day about 200 miles from Boston through Portland to Salem; the *Boston Post* stated that the "voice could be heard with considerable clearness after having passed over this great distance. But owing to the unfit construction of the telephones for the duty required of them a distinctness was not attained which would allow a conversation to be carried on." Mr. De Land also states that other records show that *conversation* was successfully transmitted in 1876 a distance of 143 miles. We believe, however, that in the first commercial prospectus of the telephone issued, it was stated that 20 miles was the limit at which the company would establish telephony; on account of distortion *commercial* telephony at greater distances would have been impossible with the apparatus then in use, though possibly words were transmitted 143 miles so early as 1876.

OUR knowledge of the organs and sense of smell and of odorous substances is defective, and what there is needs systematisation. Mr. J. H. Kenneth has recently published in *Osmics* (Oliver and Boyd: 2*s.* net) the first instalment of a bibliography of the subject of 500 items which should prove useful to any one desiring to find his way into the scattered literature. There are indexes of subjects and of species of animal.

THE Ministry of Agriculture and Fisheries has recently issued in collected form the leaflets dealing with diseases of animals and insect pests of fruit trees. The two series are now available in bound form ("Collected Leaflets on Diseases of Animals," 1*s.*; "Collected Leaflets on Insect Pests of Fruit Trees," 10*d.*). Successful treatment and prevention, whether it be of animal or plant diseases, depends upon early and accurate diagnosis: for the correct identification of the symptoms of any complaint it is necessary to have accurate information available for reference. The leaflets of the Ministry are written with this object in view as well as to supply instructions for the best treatment. The information contained in these two booklets has been brought thoroughly up-to-date, and, in many cases, new and better illustrations than those which accompanied the older leaflets have been provided.

THE reference in NATURE of September 2, p. 324, to the excellent series of wireless telephone receiving sets which are being placed on the market by the Metropolitan Vickers Co., Ltd., contains a statement which, if uncorrected, might lead to misapprehension regarding the completeness of the apparatus sent out by the company. In referring to the simplest of the sets, the remark was made that it was not clear whether the battery was contained in the case. The set in question, however, is fitted with a crystal detector, and therefore no battery is required; and, indeed, this is one of its chief advantages. In the case of the more expensive valve sets, all the necessary batteries are included with the apparatus, for the company makes a special point of the fact that every outfit is sent out complete in every respect.

WE have received from Leslie McMichael, Ltd. (Providence Place, Kilburn), a catalogue of wireless telegraph and telephone apparatus covering a considerable range, and including not only complete receiving sets of various types, but also extensive lists of component parts and accessories from which amateurs and others can make up equipment to cover any requirements on a moderate scale. We notice in particular a very low-priced two-valve receiving set for short wave-lengths which should fulfil the requirements of broadcasting but can easily be converted to longer wave reception and greater sensibility when desired. Some of the apparatus listed has been purchased from the Disposals Board and is offered at favourable prices, and a few items are marked German captured material, transformed as new. A quantity of accessories for transmitting as well as receiving apparatus is included.

Our Astronomical Column.

MARS.—An interesting example of the somewhat unusual atmospheric conditions exhibited on Mars at this apparition is described by E. C. Slipher (Pub. Ast. Soc. Pacific, Aug. 1922). This was a large white equatorial spot situated at the south end of Margaritifer Sinus; it was about 800 miles long, 400 miles wide, and comparable with the polar caps in brilliancy, though slightly more yellowish. There was no trace of it on July 8; it was very brilliant on July 9; on July 10 it was larger but fainter, and crossed by two greyish streaks; on July 11 it had split into three separate portions, of which only one, to the right of Margaritifer Sinus, remained on July 12. On July 13 and 14 the region had resumed its normal appearance. Whitish patches are frequently seen near the limbs, but they generally disappear near the central meridian, indicating that they are morning or evening mists or hoar frosts. This great spot, on the other hand, persisted in full strength throughout the Martian day. The article is illustrated by drawings and photographs, the latter being on a small scale, but fully confirming the changes in the aspect of the spot, which was probably cloud or mist. Its appearance shows that conditions on the planet's surface are by no means so stagnant as some assert.

Prof. W. H. Pickering contributes an article on the planet to *Popular Astronomy* (Aug.-Sept. 1922). It is in reply to one by Prof. Porter, and lays stress on the broad dark band that is visible round the melting polar cap; he gives good reasons for thinking that this is water, not carbon dioxide, and concludes that the day-temperature, even near the poles, is above freezing point, while at the equator it may rise to (say) 60° F. He notes the green colour of the "Maria" after the melting of the polar caps, which he, in common with many astronomers, ascribes to some form of vegetation, another indication of a temperature above freezing point. From the frequent presence of cloud or mist near the terminator, he conjectures that the nights are generally cloudy, which would tend to mitigate the severity of the night frosts. He notes that Prof. Campbell's spectroscopic observation (quoted by Prof. Porter) did not prove the complete absence of water-vapour, but only that its amount was less than a quarter of that in the earth's atmosphere.

THE LAW OF SOLAR ROTATION.—The determination of the law of rotation of the sun is an old problem, first formulated by Carrington, who studied the motions of spots as they moved across the solar disc. As sunspots are confined to middle and low latitudes, the law, based on actual data, was restricted to these latitudes. The spectroscopic method of determination was a great step in advance, because a law could be deduced which could be extended to the solar poles. Spectroscopists have, until recently, been somewhat in difficulty with their results, for determinations at different times by different observers have resulted in formulæ which did not agree. The fact is that a law formulated from observations made at, say, sunspot minimum is not applicable at a sunspot maximum, because the movements of the vapours in the solar atmosphere vary from year to year. This question of the variability of the sun's rotation during a cycle of solar activity was raised last year by Prof. Newall (Mon. Not. R.A.S., vol. 82, p. 101), and in the current number of the same publication (vol. 82, p. 479) Dr. Halm now clearly shows that "the same law of rotation of the reversing layer can be expected only under similar conditions of activity." He shows a very impressive series of curves, illustrating the angular velocities for about every ten degrees of solar latitude for each year from 1901 to 1914, excluding 1910. In these the angular velocity increases rapidly from sunspot minimum (1901) to sunspot maximum (1905), and then more slowly decreases to sunspot minimum (1913); the amplitude being much more pronounced for high than for low heliographic latitudes. These results are based on observations made at Upsala, Edinburgh, Mount Wilson, and Ottawa.

SUNSPOT IN HIGH LATITUDE.—A small sunspot was noted at Mt. Wilson on June 24 in latitude 31° north, longitude 8° east. No spot has been seen in such a high latitude since December 1919, and it is considered to be the first spot of the new cycle. It will be remembered that the equatorial spots of the expiring cycle continue for a year or more after the commencement of the new one, so that the actual minimum may not be reached till next year. The above spot was of negative polarity, whereas most of the single northern spots in the expiring cycle were positive. This is a further argument, though not a decisive one, for the spot belonging to the new cycle.

Research Items.

THE DATE OF STONEHENGE.—In the September issue of *Man* Rear-Admiral Boyle T. Somerville discusses a previous article in that journal by Mr. Stone on the date assigned by Sir Norman Lockyer, through astronomical means, for the building of Stonehenge. He points out in detail the limitations which surround the dating of prehistoric monuments by means of bearings of sunrise or sunset. There are also at Stonehenge two circles, one apparently considerably more ancient than the other. Neither of these stands on the arc of a true circle, and consequently it is not possible to discover the accurate centre, nor any given diameter of either of them. The remains of the earthwork vallum do not lie on parallel lines, nor does either wall appear to be straight. A difference of date of 1000 years is effected by the movement of the observer of only one foot to left or to right of what may originally have been the true point of observation within the circle. The result is that the attempt to date either of the circles at Stonehenge by the azimuth of the midsummer sunrise is useless, as the present condition of ruin of the monument is too great to lay out from the ground-plan of either circle an orientation line of sufficient accuracy. If the orientation towards Silbury Hill can be considered a probability, as it was by Sir Norman Lockyer, the limits of date given by him, namely 200 years on either side of 1680 B.C., are justified for whichever circle to which it related.

ARAB ART IN AMERICA.—The University Museum, Philadelphia, is in the fortunate position of being able to spend largely on additions to its collections. In the March issue of its *Museum Journal*, Mr. G. B. Gordon describes some examples of Arab art which have recently been acquired. Two mosaic fountains of fifteenth-century work are charming, and are appropriately placed in a room decorated with a wonderful wooden door with carved ivory inlay from fourteenth-century Cairo. The ornamentation of this door is singularly beautiful, the style combining small pieces dove-tailed together, the result of the scarcity of large blocks of suitable wood in Egypt. There are also some examples of Rhodian, Damascus, and Samarkand tiles, which are finely reproduced in colour to illustrate the article. Mr. Gordon gives some useful notes on the development of Arab art, especially in connexion with the taboo of human and animal forms prescribed in Islam. At Fostat, near Cairo, a rubbish heap in the town, abandoned in the thirteenth century for the present capital, has yielded some curious fragments of early Arab pottery, of which examples are also reproduced in colour.

ORIGIN OF ANIMAL PIGMENTS.—That animals in general are, directly or indirectly, dependent upon green plants for their supplies of energy is one of the most widely recognised generalisations of biological science. The importance of chlorophyll in the animal economy, however, seems to be by no means limited to the problem of food-supply. It is extremely doubtful whether chlorophyll is ever actually formed by the animal body itself, but it is very extensively taken in with vegetable food, and then apparently forms the basis from which a large number of animal pigments are built up, including the widely distributed respiratory pigment, hæmoglobin. Such, at any rate, is the finding of Mr. John F. Fulton, Jr., who contributes an interesting paper on "Animal Chlorophyll: its Relation to Hæmoglobin and to other Animal Pigments" to the current number of the *Quarterly Journal of Microscopical Science* (vol. 66, Pt. II.). It would appear from these results that a vast number of animals are dependent upon green plants for their ability to carry on the function of respiration as well as that of nutrition.

SOURCES OF VITAMIN A.—In the *Biochemical Journal* (vol. xvi., No. 4) a paper appears under the names of H. L. Jameson, J. C. Drummond, and K. H. Coward, giving an account of the work in which Dr. Jameson was engaged at the time of his death. Previous work by the other two authors had shown that vitamin A is produced in green plants by the action of light. Animals are apparently unable to make it for themselves, and since the liver of fishes is one of the best sources of this vitamin, it was of interest to follow the course of its transfer to this place. In the present paper it is shown that a pure culture of the diatom Nitzschia produces the vitamin under the action of light. Various molluscs were also found to contain it in considerable amounts. In a further paper in the same number of the journal, Prof. Drummond, Dr. Zilva, and Miss Coward show that the small organisms of animal nature making up the plankton on which small fish feed contain vitamin A in abundance, no doubt derived from the diatoms on which the plankton feed. Thus the cycle in marine life is complete. Whether this vitamin is identical with that preventing the onset of rickets is made somewhat doubtful by a paper in the *Journal of Biological Chemistry*, vol. 53, p. 293, by McCollum, Simmonds, Becker, and Shipley, in which it is shown that the vitamin A of cod-liver oil can be destroyed without depriving the oil of the substance which causes utilisation of calcium and its deposition in the bones. It may be that it is this "vitamin" that is produced in the human infant under the action of light.

ANOMALOUS STORM TRACKS.—A communication is made on this subject to the *U.S. Monthly Weather Review* for March by Mr. E. H. Bowie of the U.S. Weather Bureau. The author criticises the explanation of the paths of cyclones given in the text-books, and remarks that it would simplify the work of forecasters if cyclones behaved in an orderly manner. The paths are shown of five exceptionally erratic cyclones, and especial care has been taken to ensure the accuracy of the charted positions of the storm centres. The erratic paths given traverse the eastern United States; one storm was of West Indian origin. Each of the tracks formed one or more loops, and in forming the loop the turning in all cases was counter-clockwise. Some notes on the erratic paths of the storms are added by Prof. A. J. Henry, chiefly with the object of stimulating discussion. He notes that the temporary blocking in the path of the cyclone takes place in the neighbourhood of water surface, and in each case of temporary blocking, except in that of the West Indian storm, pressure rose over the Canadian Maritime Provinces.

CLIMATE AND PHOTOGRAPHY.—An article by Mr. H. G. Cornthwaite on this subject appears in the *U.S. Monthly Weather Review* for March. The wide variations in the strength of daylight with the time of day, season of the year, conditions of the sky, and with latitude and altitude, as well as the effects of temperature and humidity on photographic and chemical processes, are recognised and discussed. The actinic light is naturally brightest when the sun is at or near the zenith, and it dims rapidly with increased obliquity of its rays. The seasonal variation due to this cause is said to be too often overlooked or underestimated by amateur photographers, the strength of the light being about twice as great in summer as in late autumn or winter. It is mentioned that during heavy rainfall the light is photographically stronger than in densely cloudy weather without rain, due to the light reflected from the falling raindrops. Tropical daylight is asserted to be about twice as strong photographically as summer daylight in latitude 40°, and about four times as bright as winter daylight at this latitude. The light is much brighter along the sea coast than inland. Chemical activity in developing and fixing processes is greatly increased with high temperatures, and correspondingly retarded with low temperatures. Photographic films and prints may be subjected either to high temperatures or high humidity without excessive deterioration, but not to both in combination. Both prints and films are said to deteriorate rapidly in the moist tropics, but those developed and fixed under tropical conditions have a greater permanence in the tropics than those developed and printed in the temperate zone and subsequently taken to the tropics.

ELECTRICAL RESISTIVITY OF STEELS UNDER STRESS.—The recent researches of Bridgman have shown that under hydrostatic pressure the resistivity of steels decreases, while the earlier work of Tomlinson on stretched steel wires showed that under tension less than the elastic limit the resistivity increased. According to the May issue of the Science Reports of Sendai University, Mr. Sin-iti Fukuta has, under the direction of Prof. Honda, carried the observation of the effect of tension on resistivity beyond the elastic limit, and has succeeded in showing that up to stresses of the order of 5000 kilograms per sq. cm., steels with various carbon contents increase in resistivity $1\cdot14 \times 10^{-6}$ per cent. per kilogram per sq. cm. of tensile stress, the proportionality continuing past the shoulder of the stress-strain curve. In all cases about 90 per cent. of the observed change of resistance of the specimen was due to its elongation and cross contraction.

GLASS RESEARCH.—Volume iv. of "Experimental Researches and Reports" has recently been published by the Glass Technology Department of the University of Sheffield. It comprises a series of reports by Dr. W. E. S. Turner and his staff, principally on the influence of aluminium on sodium and sodium calcium trisilicate glasses. Aluminium is shown in the first paper, No. VII., to facilitate manipulation in lamp-working and to assist in preventing devitrification. The second paper on the effect of aluminium on the annealing temperature is less convincing, as it neglects questions of time and rates of cooling. Pelouze's conclusion that as aluminium is substituted for sodium the density increases, is reversed in paper IX.; density and refraction both appear to diminish. Careful stirring has evidently been necessary to detect the small variations recorded. In determining the thermal expansion effect of silica and sodium oxide in sodium silicate glasses, a silica factor value very different from that of Schott has been obtained. In the next paper, No. XV., the effect of aluminium on thermal expansion is considered, but further research is evidently required. Two of the most practical papers deal with the relative advantages and disadvantages of limestone, burnt lime, and slaked lime in common glass batches containing soda ash and salt cake. The shrinkage, porosity, and other properties of British fireclays are discussed in paper XXIII. Comparison is made with one foreign clay only, the German Grossalmerode. In view of the present conditions it might have been well to include several of the French clays which compare favourably with Grossalmerode. Following two papers on lime-magnesia glasses, a general report on glass and one on the refractory materials, both by Dr. Turner, are reprinted. The glass industry is to be congratulated upon its close association with the University of Sheffield and the Society of Glass Technology.

PHOTOGRAPHIC SENSITOMETRY AND TESTING.—The Washington Government Printing Office has issued No. 439 of the Scientific Papers of the Bureau of Standards on the "Sensitometry of Photographic Emulsions and a Survey of the Characteristics of Plates and Films of American Manufacture," by Raymond Davis and F. M. Walters, jun. For several years the Bureau of Standards has made measurements of the characteristics of photographic light-sensitive materials, aiming at uniformity in the standardisation of methods, so that the results by various workers may be directly comparable. The present paper gives details of the principles involved in photographic sensitometry and testing generally as introduced by Hurter and Driffield and published over and over again during the last thirty years. Perhaps it is desirable to restate them to render the paper more complete. The methods of the Bureau are more original. Their light source is a 6 to 8 volt Mazda C automobile headlight with a special blue glass filter, giving 2·73 candle-power and the colour of average yearly noon sunlight at the latitude of Washington. The principal other deviation from H. and D. methods is that the Bureau of Standards defines the speed of a plate as 10 divided by the inertia, instead of 34 divided by the inertia as adopted by Hurter and Driffield to fit in with their actinometer. For colour sensitometry a replica grating is used with a slit 2 inches long, and the exposure is graduated by a disc with suitably curved apertures that is rotated close in front of the slit. The methods of making other tests are fully described. Appended are 86 charts, each dealing with a single plate and giving three characteristic curves representing the result of development for 3, 6, and 12 minutes respectively, a contrast development curve, a fog contrast curve, the fog being exclusive of the glass and gelatine, a spectrogram showing colour sensitiveness, exposure factors for several colour filters, speed, extent of the straight part of the characteristic curve, and the resolving power estimated by a standardised method. Only sensitive materials made in the United States, and practically all of these, are discussed.

SEPARATION OF ISOTOPES OF LEAD.—In the Scientific Proceedings of the Royal Dublin Society for August (vol. xvii. N.S. No. 6), Drs. T. Dillon and R. Clarke and Mr. V. M. Hinchy describe some preliminary experiments on the separation of the isotopes of lead by a chemical method. The process is based on the reaction between lead chloride and an organo-magnesium compound:

$$2PbCl_2 + 4MgRX = PbR_4 + 2MgCl_2 + 2MgX_2 + Pb.$$

Hoffmann and Wolf in 1907 had already found that when lead chloride containing radium-D reacted with magnesium phenyl bromide, most of the radioactivity was found in the metallic lead separated by the above reaction, and this was confirmed. With the two portions of lead separated, the atomic weights 207·1 and 207·3 or 207·4 were found, and it is considered that the different isotopes of lead are not identical in their chemical properties in the reaction chosen. Further experiments are in progress.

Potato Trials at Ormskirk.

SIR DANIEL HALL, Chief Scientific Adviser of the Ministry of Agriculture, presided at the public inspection at Ormskirk on August 24 of the eighth series of annual trials of new potato varieties for immunity from Wart Disease (*Synchitrium endobioticum*). In addressing the important gathering of growers and scientific workers, Sir Daniel expressed the view that the disease must inevitably spread over the whole of Great Britain. The only known protection against the disease is to plant varieties which are immune from its attacks; unfortunately the most popular of the varieties at present grown are not immune. The production of new immune varieties with good cropping, cooking, and keeping qualities is therefore essential, and it was with the view of enabling raisers to ascertain whether their new productions would resist the disease that these trials were begun in 1915. In that year 94 stocks were sent for test; the trials have been largely developed by the Ministry of Agriculture, and since 1920 have been carried out at the Potato Testing Station of the National Institute of Agricultural Botany. This season 2500 stocks were planted. In an attempt to keep the spread of the disease within bounds the Ministry issues annually a list of new varieties which have proved immune in the trials. Only listed varieties may be planted in infected soil, or sent away from infected areas for seed purposes. Before a variety is regarded as immune it must have been grown at Ormskirk for two consecutive seasons without succumbing. Supplementary one-year trials of small stocks (not exceeding ten tubers) of seedlings are conducted for the information of raisers, but these trials are not taken into account by the Ministry in drawing up the list of immunes.

It is apparent from the results of the last two seasons that the rainfall affects the incidence of the disease. In the dry summer of 1921 the disease appeared very late, and its attacks were less severe; this season, with much rain, the disease has appeared earlier and is very marked. Of the 91 new stocks that are being tested for the second season, 19 have so far succumbed, though they escaped last year.

There are 123 stocks under trial for the first time this season: 58 have already succumbed and 48 cannot be distinguished from previously existing varieties. The number of varieties entered as new but in fact identical with older varieties is, however, much smaller than in previous years owing to the activities of the Synonym Committee of the National Institute of Agricultural Botany. The one-year seedling trials occupy 1700 of the 2500 plots, and 500 are planted with stocks of established varieties for demonstration purposes.

The Institute is also conducting, for the second year, trials to establish the relative dates of maturity of nine important first early varieties, and the influence of source of seed on date of maturity and yield. The trials are composed of three chequer boards, one consisting of all 9 stocks drawn from 8 different districts, one of all 9 stocks from one district, and the third of one stock drawn from all 8 districts. The results should also be of value in indicating the most accurate method for conducting yield trials.

International Reunion of Chemists at Utrecht.

ON June 21, 22, and 23 there was held at Utrecht an international reunion of chemists, which was organised by Profs. Ernst Cohen, H. R. Kruyt, and P. van Romburgh, of the University of Utrecht. Among those also present may be mentioned:—Abel (Vienna), Backer (Groningen), Baly (Liverpool), Billiter (Vienna), Bjerrum (Copenhagen), Bodenstein (Hanover), Blanksma (Leiden), Bredig (Carlsruhe), Brönsted (Copenhagen), Centnerschwer (Riga), Dennis (Ithaca, N.Y.), Donnan (London), Dubsky (Brünn), Emich (Graz), Hahn (Berlin-Dahlem), Holleman (Amsterdam), MacInnes (Cambridge, Massachusetts), Jaeger (Groningen), Jorissen (Leiden), Kailan (Vienna), Klemenc (Vienna), Lewis (Liverpool), Noyes (Urbana, Illinois), Petersen (Copenhagen), Pfeiffer (Bonn), Piccard (Lausanne), Pregl (Graz), Reinders (Delft), Schenck (Münster), Schilow (Moscow), Schlenk (Berlin), Šimek (Brünn), Skrabal (Graz), Stock (Berlin-Dahlem), Walden (Rostock), Wegscheider (Vienna), Wieland (Freiburg in Breisgau), and Winther (Copenhagen).

During the scientific meetings a number of very interesting papers were read, which gave rise to good discussions. Among these may be mentioned the following: photochemical catalysis (Baly); the photochemical combination of hydrogen and chlorine (Bodenstein); free radicals (Walden); contributions to the chemistry of the free radicals and the variable affinity-value of the carbon linking (Schlenk); free radicals (Wieland); positive and negative valence (Noyes); the preparation and properties of metallic germanium (Dennis); absorption colours of the second order (Piccard); and adsorption and distribution (Schilow).

The chemists attending the meeting received the heartiest of welcomes and the most lavish hospitality from their Dutch colleagues, who arranged a series of lunches, dinners, and excursions. Few of those who were present will ever forget the splendid hospitality of Holland, the excellence of the arrangements, and the atmosphere of good fellowship which characterised the meeting.

On the afternoon of the second day a reception was given by the Dutch Chemical Association, while on the afternoon of the last day the members were invited to tea by Count Dr. van Lynden van Sandenburg, Governor of the Province of Utrecht, and Countess van Lynden van Sandenburg. The meeting concluded with a banquet at the Badhotel, Baarn, which was preceded by a visit to the beautiful Botanic Gardens of the University of Utrecht.

The heartiest thanks of all the chemists who attended the meeting are due to Prof. Ernst Cohen, who acted as a most genial and efficient president, to his collaborators, and to all those in Holland who subscribed so liberally towards the expenses of the reunion. It was felt by all present that Holland had done in the most graceful way a noble piece of work towards the promotion and restoration of that international friendship of science which is of such vital importance for the world.

F. G. D.

Summary of the Theory of Relativity.

By Prof. H. T. H. PIAGGIO, University College, Nottingham.

I. BREAKDOWN OF OLDER THEORIES.—The older electromagnetic theory of moving bodies did not agree with experiment, or even with itself. For example, the theory of a magnet moving in a straight line towards a fixed conductor gave results quite different from those of the theory of a conductor moving in a straight line with the same velocity towards a fixed magnet. Yet experiment showed that the results should be the same, depending only on the *relative* velocity. Again, the æther was assumed to be at the same time quite unaffected by the earth's motion (to explain aberration), partly affected (to explain Fizeau's water-tube experiment), and entirely affected (to explain the experiments of Michelson and Morley, Lodge, Rowland, Rayleigh and Brace, Trouton and Noble, and others).

II. FUNDAMENTAL ASSUMPTIONS OF EINSTEIN'S RESTRICTED THEORY (1905).—This takes over Maxwell's theory so far as it applies to bodies at rest relative to the earth and deals with other systems by the two following assumptions:

(1) All electrodynamical and optical equations which hold for a system S hold also for another system S′ which, relative to S, moves with uniform velocity v in a straight line.

(2) Light is propagated in a vacuum with a velocity c which appears the same for observers in S and S′.

Kinematical deductions from these assumptions.—These imply that the measures of time and space in S and S′ must be such that

$$x^2+y^2+z^2-c^2t^2=x'^2+y'^2+z'^2-c^2t'^2,$$

from which, taking the corresponding axes in each system to be parallel and the relative velocity to be along Ox (or Ox'), we can prove that

$$x'=\beta(x-vt),\ y'=y,\ z'=z,\ t'=\beta\left(t-\frac{vx}{c^2}\right)$$

$$\text{where } \beta=\left(1-\frac{v^2}{c^2}\right)^{-\frac{1}{2}}. \quad \text{(A)};$$

hence two observers, one in S and one in S′, will *each* imagine

(i.) that a rod along Ox (or Ox') in the other's system has contracted in the ratio $\beta : 1$;

(ii.) that the other's clocks (supposed controlled by light signals) lose, taking β seconds instead of 1 for a beat;

(iii.) that the events which the other takes as simultaneous are not so.

What they will agree about is the velocity of light, c, their own relative speed, and the *interval* between two sets of values, x, y, z, t, for two events, this *interval* being defined as

$$\sqrt{\{c^2(t_2-t_1)^2-(x_2-x_1)^2-(y_2-y_1)^2-(z_2-z_1)^2\}},$$

which may be written,

$$\sqrt{\{c^2dt^2-dx^2-dy^2-dz^2\}}.$$

It is generally denoted by ds.

From equations (A) $\dfrac{dx'}{dt'}=\dfrac{\frac{dx}{dt}-v}{1-\frac{v}{c^2}\frac{dx}{dt}}$, so that if the velocity of the body moving along Ox (or Ox') is V in the system S and V′ in the system S′

$$V'=\frac{V-v}{1-\frac{vV}{c^2}},\ \text{or}\ V=\frac{V'+v}{1+\frac{vV'}{c^2}}.$$

This is confirmed by Fizeau's water-tube experiment, and (it is claimed) by Majorana's moving mirror experiment. From this formula we see that by combining two velocities V′ and v, each of which is smaller than c, we obtain a velocity V which is always smaller than c. (The statement that "*no velocity can exceed c*" is too sweeping; the velocity of light in a thin metal prism exceeds c.)

Electrodynamical deductions from these assumptions.—Transforming Maxwell's equations for free space in which electrons move with velocity V along Ox we get from assumption (1) and equations (A) that

$$\left.\begin{aligned} E'_x&=E_x, & H'_x&=H_x \\ E'_y&=\beta\left(E_y-\frac{v}{c}H_z\right), & H'_y&=\beta\left(H_y+\frac{v}{c}E_z\right) \\ E'_z&=\beta\left(E_z+\frac{v}{c}H_y\right), & H'_z&=\beta\left(H_z-\frac{v}{c}E_y\right) \\ \rho'&=\beta\rho\left(1-\frac{vV}{c^2}\right). \end{aligned}\right\} . \quad \text{(B)}.$$

The expression for ρ' gives the remarkable result that the charge on an electron appears the same in both systems. From these we can deduce:

(i.) Doppler's effect in the modified form—

$$f'=f\left(\frac{1-\frac{v}{c}}{1+\frac{v}{c}}\right)^{\frac{1}{2}},$$ where v is the relative velocity in the line of sight, f and f' the frequencies;

(ii.) a modified law of aberration;

(iii.) the force exerted by light on a moving mirror;

(iv.) the electric and magnetic fields due to a uniformly moving electron.

The differences between these forms and those given by older theories are too small to be detected by experiment.

Dynamics of an electron (slowly accelerated).—With the *additional assumption* that every electron has a constant m associated with it, such that *force* = $m\times$ *acceleration* at the instant when the electron is at rest in the system of co-ordinates used (and only at that instant), we deduce that in any other system the equations of motion are

$$\left.\begin{aligned} m\beta^3\frac{d^2x}{dt^2}&=eE_x, \\ m\beta\,\frac{d^2y}{dt^2}&=e\left(E_y-\frac{v}{c}H_z\right), \\ m\beta\,\frac{d^2z}{dt^2}&=e\left(E_z+\frac{v}{c}H_y\right), \end{aligned}\right\}$$

where e is the charge on the electron and the axis of x is taken in the direction of its velocity v. The second and third of these equations are confirmed by Bucherer's experiments.

If, with Lorentz, we take the right-hand sides as the components of the force, and retain the old law *force = mass × acceleration*, we find it necessary to speak of a longitudinal mass $m\beta^3$ and a transverse mass $m\beta$.

But we may rewrite the left-hand sides in the symmetrical form $\dfrac{d}{dt}\left(m\beta\dfrac{dx}{dt}\right)$, $\dfrac{d}{dt}\left(m\beta\dfrac{dy}{dt}\right)$, and $\dfrac{d}{dt}\left(m\beta\dfrac{dz}{dt}\right)$.

This suggests the definitions:

mass (M) = mass at low speeds × β (both for longitudinal and transverse mass);

momentum = mass × velocity;

force = rate of change of momentum.

Defining work in the usual way from force and displacement, we can further deduce:

Work done on an electron = increase of its kinetic energy, provided that kinetic energy is defined as Mc^2 + a constant = $m\beta c^2$ + a constant.

If we take the constant equal to $-mc^2$, this new definition reduces to $\frac{1}{2}mv^2$ approximately for small values of v/c. From Maxwell's equations we can derive four relations for an isolated system of electrons which may be interpreted as the conservation of momentum and of energy, provided that the momentum and energy of the electrons are defined as above, and that the momentum and energy of the field are included, the momentum of the field per unit volume being defined as Π/c^2, where Π is Poynting's vector. Observations on the spectral lines of hydrogen, and Guye and Lavanchy's experiments on cathode rays, confirm these results.

III. FUNDAMENTAL ASSUMPTIONS OF EINSTEIN'S GENERALISED THEORY (1915).—(1) For an infinitely small region of space and time, axes may be chosen so that the restricted theory is true in that region. This implies that for two events there exists a certain absolute quantity, the interval ds, which, by a *suitable* choice of co-ordinates, may be expressed as before, but which in a general system of co-ordinates, $x_1\ x_2\ x_3\ x_4$ (these being arbitrary functions of $x\,y\,z\,t$), take the form $\sqrt{(\Sigma_r\Sigma_s g_{rs}dx_r dx_s)}$, where r and s take all values from 1 to 4, and the g's are functions of $x_1\ x_2\ x_3\ x_4$.

(2) All physical laws must be expressible by means of equations which are valid for all co-ordinate systems. That is to say, the equations are covariant, or unaltered in form, for the most general transformation (not necessarily linear). Newton's law of gravitation and all other laws that do not satisfy this condition are to be modified so as to conform with it.

(3) *The Principle of Equivalence.*—A gravitational field of force at a point or infinitely small region is exactly equivalent to a field of force introduced by a transformation of the co-ordinates of reference, so that by no possible experiment can we distinguish between them. (Eddington pointed out that the assumption is made for phenomena which depend on the g's and their first differential coefficients, and in general it will *not* apply to those involving second differential coefficients.)

(4) The path of a particle in a gravitational field is such that $\delta\int ds=0$. (For the case when there is no gravitation this reduces to Newton's first law of motion.) This assumption reduces particle dynamics to something like the geometry of geodesics on surfaces, except that we have four independent variables instead of two.

(5) Although the coefficients in the expression for ds^2 are capable of infinitely many forms, according to the system of co-ordinates used (just as in measurements on a surface the square of the shortest distance on the surface between two points can be similarly expressed in many forms corresponding to the choice of the independent variables), yet these g's are not quite arbitrary functions of the co-ordinates, but satisfy a set of partial differential equations (analogous to those which for a surface express intrinsic properties of that surface). These differential equations are *assumed* to be of a certain particular form, known as those expressing the vanishing of the *contracted Riemann-Christoffel* tensor. (A tensor may roughly be defined as a generalised vector. If all its components vanish in one system of co-ordinates, they all vanish in any other system.) This assumption is not quite as arbitrary as it looks, for it is the second simplest set which is of the covariant form required by assumption (2). The simplest set of all corresponds to the absence of any gravitational field.

(6) The energy of a gravitational field exerts gravitating action just like ordinary masses. This assumption leads to equations which may be interpreted as implying the conservation of momentum and energy, including contributions due to the gravitational field (and to the electromagnetic if present).

Mathematical Deductions from these Assumptions.—(*a*) *Formulæ for the Interval.*—By solving the differential equations the g's may be obtained. The number of solutions is infinite. For a single heavy mass, choosing the units so that c and the gravitational constant are unity,

Schwarzschild gave

$$ds^2=\left(1-\frac{2m}{r}\right)dt^2-\left(1-\frac{2m}{r}\right)^{-1}dr^2-r^2d\theta^2-r^2\sin^2\theta d\phi^2.$$

F. W. Hill and G. B. Jeffery gave

$$ds^2=\frac{\left(1-\frac{m}{2r}\right)^2}{\left(1+\frac{m}{2r}\right)^2}dt^2-\left(1+\frac{m}{2r}\right)^4(dr^2+r^2d\theta^2+r^2\sin^2\theta d\phi^2).$$

and Painlevé has given a great variety.

(*b*) *Perihelion of Mercury.*—From any of these forms and assumption (4) we can by the Calculus of Variations determine the orbit of a planet. The orbits so deduced differ very little from those calculated on the Newtonian laws. The only difference big enough to be observed is that for Mercury. Leverrier estimated that the older theory differed from observation by about 43″ per hundred years. Einstein's theory accounts for these 43″. (But Grossmann (1922) has recalculated the old discrepancy as 38″, not 43″.)

(*c*) *Deflection of Ray of Light by Sun's Gravitational Field.*—The rays should be slightly curved, as if the gravitational field round the sun were a converging lens, thus making stars on opposite sides of the sun appear farther apart than when the sun is in another part of the sky. The result of the measurements made during the solar eclipse of May 29, 1919, agreed very closely with Einstein's predictions. This is strong evidence in support of Einstein's modification of the Newtonian law, as on the old law the deflection should be only half the amount predicted by Einstein and actually observed.

(*d*) *Spectral Shift.*—Einstein believes that the formula for ds^2 implies that the spectral lines in the light coming to us from the surfaces of big stars should appear shifted towards the red end of the spectrum. Eddington and others think it possible that this argument may be founded on an assumption which may be rejected while the rest of the relativity theory is retained. Grebe and Bachem (Bonn) claim to have observed the predicted effect, and so do Perot and Buisson and Fabry ; St. John claims to have shown that it does not occur, but his results have been doubted. The experimental difficulties are enormous.

(*e*) *Apparent Contraction of a Rod placed radially in a Gravitational Field.*—Einstein deduces this from the formula for ds^2 and also deduces that there is no such tangential effect. Painlevé (1921) strongly objects to these deductions and points out that by taking other forms of ds^2 we can reject these conclusions, while retaining all the verifiable results of the theory. If Einstein's views are correct, Euclidean geometry (*e.g.* Pythagoras's theorem) is not exactly true for measurements made in a gravitational field. It will be replaced by Riemann's geometry.

IV. EINSTEIN'S COSMOLOGICAL THEORY (1917).—The leading feature of this is that our universe, *as measured by material rods or light rays*, is finite, so that a ray of light will never get more than a certain distance from its starting-point. However, he is willing to admit that other universes may exist outside this limit, but such that their light can never meet ours. Eddington and others regard this theory rather unfavourably.

V. EINSTEIN'S VIEWS ON THE ÆTHER (1920).—Space is endowed with physical qualities. In this sense, therefore, there exists an "æther." Without it there would be no propagation of light. But this æther may not be thought of as endowed with the physical properties of material media. It must not be considered as either fixed or moving. No explicit use of any conception of the æther is made in the theory of relativity. It is difficult to see what use could be made of the above views, which are chiefly negative. The phenomena of the gyroscope and Foucault's pendulum (and Sagnac's optical experiment), which on the Newtonian ideas are attributed to absolute space, are attributed by relativists to the æther or the effects of the fixed stars—which is rather unconvincing.

VI. WEYL'S EXTENDED THEORY (1918).—Whereas Einstein's interval depends only upon gravitational phenomena (although Maxwell's equations and all electromagnetic effects fit into the framework thus constructed), Weyl assumes that the length of the measuring rod depends upon the route it has taken in the neighbourhood of electromagnetic fields. When these are present, the interval is no longer a definite quantity (thus weakening the argument for the spectral shift). This theory accounts for Maxwell's equations and introduces Einstein's cosmological term in a natural way, and adds the law of conservation of electricity to those of conservation of momentum and energy. On the other hand, it introduces great complexity into geometry and appears to imply the impossibility of metrology, beyond a certain—very high—degree of accuracy. There is no experimental confirmation. Einstein does not accept it. Eddington (1921) has generalised Weyl's mathematics, but says, " Einstein's postulates and deductions are exact. The natural geometry of the world . . . is the geometry of Riemann and Einstein, not Weyl's generalised geometry or mine."

VII. PAINLEVÉ'S SEMI-EINSTEINIAN THEORY OF GRAVITATION (1922).—This retains Euclidean geometry and the old ideas about space and time. By axioms which are somewhat similar to those of Einstein, but which make no reference to the restricted theory, Schwarzschild's form of ds^2 and the verified astronomical results are obtained.

Kitchen Ranges.

THERE is probably no more difficult problem presented to the heating engineer than the kitchen range. So complicated is it that it would appear that no single appliance could possibly be constructed to suit every house or even any large number of houses, and that each installation would have to be adapted to the requirements of the special household. For example, a working-man's cottage usually requires only one fire, which, in the absence of a gas cooker, must satisfy the quadruple duty of heating the room, the oven, the hot-plate and the water, whereas a better class of house might use, and with greater economy, a gas cooker and a coke boiler for the supply of hot water and radiators. Then, again, in an ordinary household, cooking is an operation occupying two or three hours per day only, while hot water is likely to be required at any moment throughout the day. Heating of the rooms is required continuously all day in winter, but not at all in summer. The inevitable consequence of such an intermittent demand is a low efficiency.

We have before us two important pamphlets embodying the researches of Dr. Margaret Fishenden and Mr. A. H. Barker carried out under the auspices of the Fuel Research Board.[1] Dr. Fishenden has restricted her investigation to the comparative efficiency of ranges fired with ordinary bituminous coal and those heated with the special coke cakes (low temperature coke) produced by the Fuel Research Station at E. Greenwich. She finds that low temperature coke yields a greater proportion of total heat for radiation or for water heating than bituminous coal, while for oven heating the coke compares less favourably with coal, the advantage of coke being largely due to radiation effects. She finds, moreover, that in an open kitchen range with back boiler about 17 per cent. of the heat of the coal is used for hot water, and in modern designs it varied from 13 to 19 per cent., a result rather higher than that found by Mr. Barker.

It is unfortunate that Dr. Fishenden's experiments do not include ordinary coke, as the low temperature coke prepared by the Fuel Research Board is a commodity not yet on the market and unlikely to appear there, as it is obviously too costly to compete at present with either coal or coke. The report of Mr. Barker (who is lecturer on heating and ventilating engineering at University College, London) deals in a very comprehensive fashion with the whole subject of kitchen ranges, and the results of a large number of practical tests on old and new designs using coal, coke, and gas as sources of fuel. The introduction to the report contains the following statement: " In the design of British cooking ranges, attention has hitherto been mainly devoted to securing cheapness of construction and convenience of use. Economy in fuel consumption has only played a minor part in determining the different types in use. The shortage and high price of coal have, however, emphasized the necessity for fuel economy and, consequently, of an examination of the efficiency of British kitchen ranges. . . . The strong prejudice in favour of an open-fronted fire appears to be peculiar to this country. In most other countries a cooking range fire is usually closed. . . . In view, therefore, of the scarcity and high price of coal at the present time, it appears to be a matter for serious consideration whether steps should not be taken to encourage the more general adoption in this country of ranges which are more economical in fuel consumption than those of ordinary British design."

In his general summary Mr. Barker has arrived at the following conclusions: that the general efficiency of all ranges on the market at the present time is low, the actual oven efficiency ranging from 0.75 to 5 per cent., the usual being about 2 per cent., that of the hot water supply from 7 to 17 per cent. or usually 11 per cent., and the hot plate from 1 to 12 per cent. or generally below 6 per cent. He estimates that the modern type of range wastes 85 per cent. of the fuel in heating the air of the kitchen (about 30 per cent.), by absorption in the brickwork (about 30 per cent.), and lost in the flue gases (about 25 per cent.). Economy may be effected by not setting ranges in brickwork, by preventing leakage of cold air into the furnace and flues, and by doing away with the hot-plate or covering it when not in use, and also the oven door, with non-conducting material. He admits, however, that these losses are unavoidable if the present convenience and cheapness of the ordinary range are to be retained and one fire made to serve so many different purposes. But if the efficiency is considered irrespective of convenience, cheapness,

[1] (1) The Efficiency of Low Temperature Coke in Domestic Appliances, by Dr. Margaret W. Fishenden. Fuel Research Board, Technical Paper No. 3. London: H.M. Stationery Office, 1922. 9*d*. net.
(2) Tests on Ranges and Cooking Appliances, by A. H. Barker. Fuel Research Board, Special Report No. 4. London: H.M. Stationery Office, 1922. 2*s*. 6*d*. net.

and space, then it would be necessary to have separate fires for oven, hot water, and hot-plate. This is obviously impracticable; but, on the other hand, in a well-insulated oven heated over a small fire without excess of air by leakage, an efficiency of 30 per cent. might easily be achieved, and, he adds, "there is no reason why a whole dinner could not be cooked in such an oven with 2 lbs. of fuel." But beyond 40 or 50 per cent. efficiency in the oven it is impossible to go, and the ideal conditions can be attained only by electrical heating.

The adoption of an independent boiler would raise the efficiency of the fuel for the hot water supply from an average of 8 to 10 per cent. to 40 to 45 per cent., a figure which Dr. Fishenden gives for a coke-fired boiler. On the other hand, for a small household such a boiler is too large, and a small boiler is difficult to fire and keep alight, especially with coke.

The principal cause of loss from a hot water equipment is not so much the low efficiency of the apparatus as the subsequent loss of heat from the storage vessel by radiation. Hot water should be generated when it is required, and this can be done only by gas as in the gas geyser, which is efficient and useful though clumsy and dangerous. If the appliance can be so arranged that the fire can be lighted and burn itself out, a sufficient supply of hot water would be produced for a whole day's use provided the heat was not allowed to escape by proper insulation.

The report contains a lot more useful, practical information as to the method of installation, but perhaps the most significant and encouraging part of the report is the improvement in efficiency which Mr. Barker has himself effected in ranges of his own design whereby he has reduced the fuel consumption by about 70 per cent. It is to be hoped that this new type of range will soon be placed on the market.

J. B. C.

University and Educational Intelligence.

LEEDS.—The hon. degree of Doctor of Science has been conferred on the following: Sir Charles Scott Sherrington, G.B.E., president of the British Association; the Duc de Broglie, Institut d'Optique, Paris; Dr. C. G. Joh. Petersen, director of the Danish Biological Station, Copenhagen; and Prof. P. Weiss, director of the Institut de Physique, University of Strasbourg.

LONDON.—Mr. T. A. Stephenson of Kingswood School and University College, Aberystwyth, has been appointed assistant in the department of zoology and comparative anatomy at University College.

A programme of public lectures, admission to which is free and without ticket, to be delivered at University College during the coming term, has been issued. It includes lectures on social life in Egypt by Prof. Flinders Petrie, on recent excavations in Malta by Miss M. A. Murray, on the beginnings of science by Prof. G. Elliot Smith, on the nature of intelligence by Prof. C. Spearman, and a series of lectures on phonetics, including one on the nature and reproduction of speech sounds by Sir Richard Paget. At King's College there will be a course of ten lectures by Prof. H. Wildon Carr, commencing on October 5, on the new method of Descartes and the problems to which it gave rise; five lectures by Miss Hilda D. Oakeley on the Stoic philosophy, commencing on November 9; one lecture on October 9, at 5.30, by Prof. G. B. Jeffery on Einstein's theory of relativity; six lectures, commencing October 17, on modern hydro-electric engineering practice by E. M. Bergstrom; and three lectures, commencing November 28, on the fuel problem from an engineering standpoint by Dr. C. H. Lander. Complete lists of the lectures can be obtained on application, enclosing a stamped addressed envelope, to the secretary of the college in question.

AN article on "The New University of London," by T. Ll. Humberstone, appears in the *English Review* for September. After showing that so far back as the twelfth century there existed in London all the necessary elements for the formation of a great university, and speculating as to the reasons why, nevertheless, it was not until the nineteenth that one came into being, the writer describes the establishment of the University of London as an examining board in 1836 and its reconstitution as a teaching university in 1900. Of the "third incarnation," now inaugurated with the gift by the Government of eleven and a half acres of land adjoining the site of the British Museum, he writes: "Our task is to open a new Pierian spring to quench a world-thirst": the new university of London is destined to play a great part in the re-establishment of the cosmopolitan spirit which, under the influence of the Roman Church, tended in the Middle Ages to make Europe a single nation. Time will show whether these aspirations, stimulated by Mr. Fisher's speech at University College last February, can be realised. Meanwhile there is one obstacle, easily removed, to which attention was directed at the recent conference at Basle of delegates from British and Swiss universities. There London's policy in regard to the admission of foreign students was criticised as illiberal. Why, it was asked, should London insist on verifying, by a special matriculation examination, the attainments of students who hold certificates qualifying for admission without further examination into the universities of Switzerland, and implying matriculation standards of attainment in the subjects of the London examination? Cambridge has lately adopted a comprehensive exemption formula recognising the sufficiency of the standards implied by such foreign certificates, and it was hoped that London would do likewise.

THE University of Colorado Catalogue, 1921–22, issued in March 1922 with announcements for 1922–1923, presents several interesting features, exemplifying recent developments in American State universities. The University Extension Division, organised in 1912, "aims to make the campus of the university co-extensive with the State, in keeping with the new idea that a State university exists for all the people and not for a favoured few alone." It has a Faculty comprising 12 administrative and secretarial officers, besides professors and instructors in the various university departments, and a non-resident staff numbering 31. Among its varied activities are: correspondence courses, in which form one-fourth of the work for the A.B. degree may be taken; class instruction, more or less on the lines of our university extension lecture courses, but qualifying equally with courses taken in the university towards degrees; courses in secondary education; social surveys of towns, with a view to the solution of community problems; business surveys for determining the commercial resources and trade possibilities of a community; visits to stores and firms "for the purpose of rendering individual assistance in meeting business problems." Quite distinct from the Extension Division is a "Summer Quarter" of ten weeks, in which are provided courses, some of post-graduate standard, in arts and pure sciences, engineering, medicine, and law. These, if pursued through the whole quarter, carry the same credit as similar courses in any other quarter.

Calendar of Industrial Pioneers.

September 24, 1852. John Barnes died.—From 1822 to 1835 Barnes was a partner with Joseph Miller, the marine engineer, and as such assisted in introducing steam navigation on the Rhône and Saône. He afterwards designed engines for vessels built by Normand of Havre, among these being the *Napoléon*, the first screw ship in the French Navy. At the time of his death he was manager of works at La Ciotat near Marseilles.

September 24, 1908. Sir Samuel Canning died.—Born in Wiltshire in 1823, Canning, after some years of railway engineering, joined the firm of Küper and Co., cable makers, of Greenwich, in 1852, and from that time onwards was intimately associated with the development of submarine telegraphy. He took part in the attempt to lay the Atlantic Cable in 1857 and 1858, and as chief engineer of the Telegraph Construction and Maintenance Company he had charge of the making and laying of the second and third Atlantic cables of 1865 and 1866. He was responsible for fitting out the *Great Eastern* and originated much of the cable machinery.

September 25, 1910. Edward Pritchard Martin died.—President of the Iron and Steel Institute and of the Institution of Mechanical Engineers, Martin was a metallurgist who, while manager of the Blaenavon Iron Works, was the first to give facilities for trying on a commercial scale the Thomas-Gilchrist process of dephosphorisation in steel-making. Martin was the son of a mining engineer of the Dowlais Iron Works, and was himself manager of those works from 1882 to 1902.

September 29, 1913. Rudolph Diesel died.—Diesel was born in Paris of German parents on March 15, 1858. He attended school in Augsburg, and at an early age became an assistant to Linde and directed works in Paris where Linde's refrigerators were constructed. Attacking the problem of making a prime mover of higher efficiency than hitherto existed, in 1893 he published "The Theory and Construction of a Rational Heat Motor," and the same year built his first experimental engine. After further trials the manufacture of Diesel engines was taken up by various firms, and to-day they are found in every part of the world. Their superior economy has led to their being fitted in ships; the s.s. *Toiler*, driven by two Diesel engines, crossed the Atlantic in 1911, while to-day more than 1600 vessels of a total tonnage of 1,500,000 tons are driven by internal combustion engines mainly of the Diesel type.

September 30, 1719. Bernard Renau d'Eliçagaray died.—The author of a treatise "Théorie de la manœuvre des vaisseaux," published in 1689, Renau d'Eliçagaray, as a naval officer, saw service afloat and ashore, and at Brest introduced new methods of shipbuilding. He took a leading part in the development of the French Navy under Louis XIV.

September 30, 1772. James Brindley died.—A native of Derbyshire, where he was born in 1716, Brindley served an apprenticeship to a millwright, and afterwards in business in Staffordshire for himself gained a reputation for his ingenuity and skill. For the Duke of Bridgewater he constructed the first British canal, that from Worsley to Manchester. This was completed in 1761, but before Brindley died he had built 365 miles of canal, including the Grand Trunk Canal from the Trent to the Mersey, thus laying the foundation of the British system of inland navigation.

E. C. S.

Societies and Academies.

PARIS.

Academy of Sciences, August 21.—M. Emile Roux in the chair.—Paul **Viullemin**: Disjunction and combination of the characters of the parents in a hybrid. Study of a hybrid of *Aquilegia cœrulea* and *A. chrysantha*.—N. **Lusin** and W. **Sierpinski**: The decomposition of the continued fraction.—H. **Mineur**: A class of uniform transcendentals.—H. A. **Perkins**: The resistance of thin electrified conducting layers. Experimental study of the effect of an electrostatic charge on the resistance of thin gold film. The film formed one plate of a condenser, and no change in the resistance could be measured with or without an electrostatic charge of 2·7 C.G.S. electrostatic units (800 volts).—F. W. **Klingstedt**: The ultra-violet absorption spectra of the diphenols. A quantitative study of the normal absorption spectra of the dihydroxybenzenes, made with the Fabry and Buisson microphotometer on photographs taken by V. Henri's method. The meta- and ortho-derivatives have spectra very like that of phenol, but the para-compound has eight nearly equidistant bands instead of the three of phenol. The spectra are modified by certain solvents: with alcohol as a solvent it is impossible to recognise the characteristic differences between the para-compound and ortho- and meta-derivatives. Hexane is the best solvent.—H. **Gault** and R. **Guillemet**: The chlorination of normal butyl alcohol. The chief product was found to be the dibutyl acetal of dichlorobutyraldehyde, $C_4H_6Cl_2(O . CH_2 . CH_2 . CH_2 . CH_3)$. This acetal is not hydrolysed by aqueous potash, and only slightly hydrolysed by hydrochloric acid or dilute sulphuric acid at 150° under pressure.—G. **Vavon** and A. L. **Berton**: The borneol obtained starting with the magnesium compound of pinene chlorhydrate.—G. **Murgoci**: The properties of the blue amphiboles.—Marcel **Mirande**: The morphological origin of the internal liber of the Nolanaceæ and the systematic position of this family. The Nolanaceæ have been placed as allied with the Convolvulaceæ or the Solanaceæ: it is shown that this family is well differentiated from the Convolvulaceæ, but may be classified with the Solanaceæ.—A. **Guilliermond**: Cytological observation on a Leptomitus and in particular on the mode of formation and germination of the zoospores.—Georges **Bouvrain**: The vascular evolution in Mercurialis.—W. J. **Vernadsky**: Nickel and cobalt in the biosphere. The constant presence of nickel and cobalt in living organisms has not been proved; but they have been found in all cases when specially sought. They have been found in all the mosses studied in the neighbourhood of Kieff, and in nine species of plants from the same district. Cobalt has also been found in *Echium vulgare* from the Crimea, and in the ashes of a domestic mouse.—Louis **Boutan**: A fine culture pearl without nucleus.

Official Publications Received.

Education Committee for the County Borough of Brighton. Municipal Technical College, Richmond Terrace, Brighton. Day Courses, Session 1922–23. Pp. 61. (Brighton.)

The Journal of the Royal Anthropological Institute of Great Britain and Ireland. Vol. 52, January to June, 1922. Pp. 149+13 plates. (London: Royal Anthropological Institute.) 15s. net.

Durham University Calendar for the Year 1922–23. Pp. 756. (Newcastle-upon-Tyne.) 3s. 6d. net.

Fortschritte der technischen Physik. Vorträge von der zweiten Jahrestagung der Deutschen Gesellschaft für technische Physik in Jena vom 19. bis 25. September 1921. Pp. iv.+111. (Leipzig: J. A. Barth.) 48 marks.