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Causes of Fluctuations in the Birth-rate.

IT is not surprising, in view of the fundamental importance of population, that the declining birth-rate, which began in England in 1876 (in France much earlier), and has now become general in most civilised countries having accurate records, has been the subject of numerous studies. At first crude birth-rates stated per 1000 of the total population were regarded as sufficing for these studies. They did so when all that was desired was to show the effect of births on the increase in population. These birth-rates, however, failed to indicate the true fertility of the population. Child-bearing in women practically occurs only between the ages fifteen and forty-five: it varies greatly in married couples, according to the proportion of married women living at different ages within these thirty years of life, and according to the duration of marriage. The age of the father has been found, in actual experience, to have an almost negligible influence.

There have been two major studies in which the subject has been investigated and correction made for these arithmetical causes of variation, one by Newsholme and Stevenson, which appeared in the Journal of the Statistical Society in 1906, and another by Mr. Udny Yule, published at the same time in the same journal. The results of these investigations are summarised in an interesting paper now before us.[1]

The facts show that the decline in the birth-rate is due chiefly to a fall in the productivity of married couples, and that this fall has been proceeding at an accelerating rate. They show also that there are great differences in the birth-rate in various social strata, and it is likely that the decline in fertility has been greatest in the professional and upper classes. It has, however, been great in many artisan circles, and especially in the textile districts.

What is the interpretation of these facts? Mr. Yule disagrees with Dr. Stevenson, of the General Register Office, in his view that the decline in fertility of married women is "due to the increasing practice of contraceptive measures." That such measures are largely practised, that they are becoming increasingly practised, that they are advocated by a large number of people who believe over-population to be the chief cause of poverty, that clinics for teaching married women contraceptive measures have been formed, and that a large mass of cheap literature on the subject is circulated, are all facts beyond dispute. The facts that the decline in the birth-rate has been greatest among the educated classes and least among agriculturists and miners, who would be less likely to be "made wise" on the subject, and that the beginning of the fall in the birth-rate corresponded in time with the Bradlaugh-Besant prosecution for publishing "The Fruits of Philosophy," undoubtedly support this view. But in Mr. Yule's opinion it is too simple an explanation; and he justly urges that even if these measures constitute the chief means for reducing fertility, they do not explain the almost universal desire for such reduction.

Is there any evidence of variations in fertility in circumstances in which contraceptive measures may be assumed not to have been in use? In some small group-inquiries this appears to have occurred, though the evidence is not conclusive. Mr. Yule's main point rests on the discovery of instances in which an increased birth-rate has occurred in circumstances in which the artificial prevention of conception in the period of lower birth-rate can be excluded. He produces a solitary instance, that of Connaught, the true fertility in which was 35 to 39 per cent. greater in 1911 than in 1881, and 6 per cent. greater in 1871 than in 1881. This being an almost purely Roman Catholic area, the use of contraceptives may probably be excluded. One may, however, doubt the accuracy of the birth statistics of this area. As pointed out in another part of Mr. Yule's paper, compulsory registra-

[1] "The Fall of the Birth-rate.' A paper read before the Cambridge University Eugenics Society, May 20, 1920, by G. Udny Yule. Pp. 43. Cambridge: At the University Press, 1920.) 4s. net.

tion of births was not enforced in England until 1875, and it is probable that for many years later both birth and death registration were imperfect and irregular in Ireland, especially in its remote parts.

It would be more satisfactory, as supporting natural changes in fertility, if other trustworthy instances could be quoted. True, Dr. Brownlee's figures for Geneva are quoted showing a decline of more than 40 per cent. in the birth-rate between the beginning of the eighteenth century and the early nineteenth century; but these figures, like some other international rates for prolonged periods, can scarcely be said to favour the view that fluctuations in the birth-rate (corrected for number of marriages and age at marriage) occur naturally. If they do occur naturally we must assume that they are physiological in character, being rhythmic variations in "germinal vitality" (Brownlee), which have been compared to the outbursts of infectivity, say, in the influenza organism, the cause of which is unknown to us, though we express our ignorance by using Sydenham's language of "epidemic influences." Mr. Yule sees no reason "why man should be exempt from analogous phenomena," but it is difficult to conceive any analogy between variations in activity of unicellular organisms and variations in sexual activity of a complex mammalian. Nor are we impressed by the suggestion of comparability of such phenomena as plagues of field-mice or plagues of locusts. These are more naturally explained on the supposition that an excessive death-rate has occurred among other creatures which would have maintained the balance of Nature; and it does not appear inappropriate to refer to the old puzzle as to the relationship between old maids, field-mice, bees, and the clover crop.

This last suggestion brings us to the most valuable section of Mr. Yule's paper. Whether contraceptive measures or other causes, not being arithmetical as explained above, have caused the reduced birth-rate, how is the birth-rate related to economic conditions? Mr. Yule is convinced that the course of prices is closely related to the trend of the marriage-rate and of fertility, though he states that he is at a loss to suggest the precise nature of the nexus. He regards the nexus as economic, probably acting *via* psychology rather than directly through physiology; and he does not believe that the nexus is wholly volitional, acting through contraceptive measures or otherwise. He regards migration, marriage-rate, and fertility as only three forms of response to demand for population.

There we must leave this momentous problem. It deserves even more study than it has hitherto received. That economic circumstances, raising the age for gainful employment and the like, have had marked influence in lowering the birth-rate is certain. That the desire for a higher standard of comfort and for a more satisfactory upbringing of a smaller family, not necessarily selfish, has been a potent factor is equally without doubt. Whether at the end of another generation the differential birth-rate will, as many fear, lower the standard of health and intelligence is doubtful. The present writer regards this fear as exaggerated. Talent emerges in all social strata; but where large families imply imperfectly nourished children and a deficiency of parental care, they must necessarily lower the average standard of health. Is this occurring for a larger proportion of the total population than in previous generations? Probably not.

Indian Land Mollusca.

The Fauna of British India, including Ceylon and Burma: Mollusca.—III. *Land Operculates.* (*Cyclophoridae, Truncatellidae, Assimineidae, Helicinidae.*) By G. K. Gude. Pp. xiv + 386. (London: Taylor and Francis; Calcutta: Thacker, Spink, and Co.; Bombay: Thacker and Co., Ltd., 1921.) 35*s*.

AMONG the Indian land mollusca the family Cyclophoridæ especially attracts attention by the beauty of form and variety in the shells. The range is extensive, and their study began so far back as 1849, when W. H. Benson, of the Bengal Civil Service, and Capt. T. Hutton were writing on the animal of Diplommatina. After seventy years the above families are still very imperfectly understood, so little is known of the animal which constructs the shell. I think I am correct in saying the time had not arrived for publishing a volume on these molluscs, for sufficient material had not been examined; in truth, much has yet to be collected. It would be interesting to know for this reason why Mr. Gude was selected to do it, and the work then left to all intents and purposes completely in his hands; why malacologists with knowledge of the subject were not consulted; and why the present writer, with more than forty years' connection with these land operculates, both in the field and in collections, was in complete ignorance that such a work was under compilation. It leads me to think of past workers in this field of natural history. The foremost among them was the late Dr. William Blanford, the editor and founder of "The Fauna of British India." No one would have known better how much preliminary work there was to do, or what material to obtain; and had he lived he would have prepared the way for it, as he did for vol. 1 of the Mollusca Series (the Testacellidæ and Zonitidæ). It recalls the type of paper he wrote on the animals of Raphaulus, Spiraculum, and other tube-bearing Cyclostomacea so long ago as 1863 in "The Annals and Magazine of Natural History." There is even now food for thought in this paper, while it is an indication of how the history of the land operculates should be approached, which is to be looked for in vain in the publication under notice.

The shells of living species should no longer be treated as if they were fossils, the animal unobservable, unobtainable; this I notice under the genera Japonia, Cyclophorus, Alycœus, and Diplommatina, pp. 6, 57, 301, 304, and 349. This neglect of the animal in classification should not thus continue. It is not up to the standard of the present day, and some advance was to be looked for, based on more recent original investigation.

Space does not admit of quoting many and various errors, but looking at the contents I begin with "The Systematic Index" and naturally turn to the genera I am best acquainted with. On p. xii I have to notice, very fully, an unfortunate, inaccurate record of species under the sub-genus Raptomphalus of Alycœus; eight species are put into it, whereas it is represented by only one, *R. magnificus*, described by me in "Land and Freshwater Mollusca of India," vol. 2, part 12, p. 366, plate 156, figs. 1, *1a*, *1b*. These figures show that in shell character it is very different and distinct from typical species of Alycœus. As yet it has been found only in the Yamne Valley, a large tributary of the Tsangpo, which comes in on the left bank, not far from the base of the mountains, in the Abor country.

Mr. Gude has extended the range of this new sub-genus enormously. One of the eight is a species from the Shan-Siam frontier, 500 miles distant, where the sub-genus cannot certainly be expected to extend. All these eight Alycœi are very variable in form, unlike *R. magnificus*. A glance at the figures will show this. A place for each of them has now to be found in the index, and all on pp. 286, 287, 288, and 289 are out of place. On p. 285 *Raptomphalus magnificus* is not the "first species"; it should be "only species."

Such a record does not help zoology; it has gone forth to the world, striking directly at the accuracy of geographical distribution, and before it can be disproved it will be used, trusted, and quoted by workers, both at home and abroad, for years to come. The record in "The Mollusca of India" from the first has been geographical. I have been at pains to show how the distribution of species living in the great valleys of the Himalayan range changes as we proceed from west to east. This was to be expected, for these great valleys are geologically ancient, isolated one from the other, and separated by great physical features, especially in the Eastern Himalaya by snow-clad meridional ridges. In age these valleys are sufficiently old to be centres of "species development." We are able to state that there is scarcely a species living in the Teesta Valley of Sikkim common to the Tsangpo Valley and Abor Hills. The molluscan fauna of the Dafla Hills is remarkable in comparison with both the above areas. Here physical geography comes in to the support of distribution, and shows how accurate the record of the latter should be made. The former tells us that while the Teesta Valley and its neighbours on the west in Nipal, and on the east in Bhutan, have drained for ages into the great depression of the Bay of Bengal, it was comparatively a recent geological change when the Brahmaputra took the same course. Indeed, all evidence goes to show that the Tsangpo originally drained into Burma; it certainly did so all through the Siwalik period, to go no further back in time. It was the elevation of the Assam range, extending from Eastern Assam to the Garo Hills, which produced this wonderful change in geography over a vast area. In Eastern Assam the Tertiary sandstones, all derived from the waste of the Himalayas, are elevated to 10,000 ft. and above. This has had everything to say to the distribution of life, particularly the molluscan, both land and freshwater, in this part of India and the eastern frontier, and affected the spread of genera and species. It explains why the molluscan fauna of the Tsangpo Valley is so restricted, and why it cannot be found anywhere, as the distribution attributed to Raptomphalus might lead some zoologists to suppose.

On geological evidence we can presume to say that the Barowli, the Dikrang, and the Ranga of the Eastern Himalaya once flowed directly to the Kyandwen, and the Subansiri and the Tsangpo to the Hkampti Long and head waters of the Irrawady. It explains the finding of certain species of Unio and Sphærium, both in Munipur and in Assam, and of the distribution of many other genera and species, including Austenia.

The volume adds very little to our previous knowledge of the land operculates of India. An opportunity has been lost of bringing that knowledge up to date. The money spent on it might have had a better result. There is an absence of editorial supervision. Mr. Guy A. K. Marshall is not mentioned in the preface; all seemingly devolved on Mr. G. K. Gude. It is purely conchological and was brought out in a hurry. It should not, in fact, have been commenced until it was first ascertained who were to be engaged upon it and what collections were available. This is most important to those who, at great expense of time and toil, collect material and desire to see it in the hands of the best malacologists and so far have a voice in the publication.

Next we have to consider the best place of publication, whether in this country or in India. I lean to the latter, for in India the animals of many genera could be collected in a few weeks as required and worked out by the staff of the Indian Museum, who are quite capable of doing so. I also consider it essential to accuracy in a record of this kind that the type shell of all species should be compared so far as possible to verify the "original descriptions" in the pages and pages of "copy" which fill the volume. This applies also to the figures given of species in the Natural History Museum and other collections. They are not typical; some have no history, and are not in all cases correctly identified.

The history of the Indian operculate land shells has yet to be compiled and a more scientific classification built up. For this reason I am disappointed with this volume of "The Fauna of British India," and imagine that among other zoologists there will be a similar feeling.

In the volume there is a mass of useful compilation, particularly in the synonymy, as well as in the bringing together of the many species in the four families treated of. This work, looked at from the purely conchological side, cannot fail to be useful to collectors.

H. H. GODWIN-AUSTEN.

Chemistry of Anthracene.

Anthracene and Anthraquinone. By E. de B. Barnett. Pp. xi+436. (London: Baillière, Tindall, and Cox, 1921.) 27*s*. 6*d*.

THE history of anthracene is long and vivid. Discovered amongst the products of coal-tar distillation in 1832, the hydrocarbon played a modest and somewhat commonplace part in the development of structural theory, suddenly blossoming into prominence in 1868, when it was found that alizarin, the twin monarch with indigo of natural colouring matters, is a dihydroxyanthraquinone. The persistent and active investigation of anthracene derivatives consequent on this revelation had scarcely slackened in 1901, when Bohn discovered the remarkable condensation undergone by β-aminoanthraquinone, leading to indanthrene and flavanthrene, vat-dyes superior in fastness to indigo itself. During the subsequent period notable additions to the series have been made in the direction of complex benzanthrones—for example, violanthrene, a non-nitrogenous vat-dye represented as an oxygenated agglomeration of nine benzenoid nuclei. Thus anthracene, now approaching its centenary, still provides abundant material for scientific investigation and practical application.

It is, therefore, most appropriate that so much information, extending over so many years, should be assembled in a form convenient for reference, and the volume which Mr. Barnett has produced will be found extremely valuable by all chemists who desire to be advised of the latest discoveries in this important field. Beginning with a comprehensive survey of the early work and the substituted derivatives of anthracene itself, the author passes to anthraquinone, anthrone, and anthranol. Treatment of the numerous hydroxyanthraquinones has been limited to the ground which is not covered by A. G. Perkin and Everest in their recent book on "The Natural Organic Colouring Matters," and thus it has been possible to devote almost half the text to aminoanthraquinones and the highly important modern discoveries to which reference has been made. It is this feature which will be most appreciated by chemists because, owing to the recent developments of anthracene chemistry having taken place principally in the German dye-factories, the relevant information is largely scattered through the patent literature, and is consequently not easy of access.

Some idea of the faithful industry which the author has brought to his task may be gained from the statement that the index to German patents so liberally quoted throughout the volume alone occupies eighteen pages, and refers to more than one thousand items, which are assembled in sequence, with the respective date and name of patentee. Constant attention is directed to those colouring matters which arise from the various classes of anthracene derivatives, thus adding to the general usefulness of the book a quality specially attractive to chemists concerned with the application and manufacture of dyes.

Praise is due also for the general index, and, excepting a few lapses into laboratory slang and the "of course" habit, the literary form is commendable. In the second edition, however, it is to be hoped that the author will establish uniformity of construction in the compound words; to find "octa-chlor anthracene" in one line, and "tetrachloranthraquinone" in the next, is exasperating to a methodical reader, and a bad example to students. This fault is persisted in throughout, and is the only blemish in an otherwise admirable treatise. M. O. FORSTER.

The Future of Geometrical Optics.

(1) *Geometrical Investigation of the Formation of Images in Optical Instruments, embodying the Results of Scientific Researches conducted in German Optical Workshops.* Edited by M. von Rohr. (Forming vol. 1 of "The Theory of Optical Instruments.") Translated by R. Kanthack. Pp. xxiii+612. Printed and published for the Department of Scientific and Industrial Research by H.M. Stationery Office, 1920. (From any bookseller or through H.M.S.O. at Imperial House, Kingsway, W.C.2, and 28 Abingdon Street, S.W.1; 37 Peter Street, Manchester; 1 St. Andrew's Crescent, Cardiff; 23 Forth Street, Edinburgh; or from E. Ponsonby, Ltd., 116 Grafton Street, Dublin.) 2*l*. 5*s*. net.

(2) *Die Binokularen Instrumente: Nach Quellen und bis zum Ausgang von* 1910 *Bearbeitet.* By Prof. Moritz von Rohr. Zweite, Vermehrte, und Verbesserte Auflage. (Naturwissenschaftliche Monographien und Lehrbücher. Zweiter Band.) Pp. xvii+303. (Berlin: Julius Springer, 1920.) 40 marks.

AT a meeting of the Optical Society held in Cambridge on May 21 last, the future of geometrical optics formed the subject of an interesting discussion, in which the points of view of mathematicians and practical designers respectively were expressed. The subject has regained actuality in recent years in view of the undoubted superiority in optical design possessed by the German manufacturers in 1914, a superiority which proved a serious handicap to us in the manufacture of optical instruments such as range-finders, etc., required for military and naval purposes. The importance of this branch of knowledge was then realised; unfortunately, before the war the subject had been gradually dropping out of university curricula, the laborious algebra involved and the stereotyped methods of treatment combining to render it distasteful to mathematical teachers and students. Relegated to a corner of the mathematical syllabus, geometrical optics was too often reduced to a few formulæ crammed in a hurry, and it lacked the vitalising influence of really interesting and practical illustrations. The manufacturing optical designer, on the other hand, tired of waiting for mathematical developments adequate to his needs, became increasingly empirical in his methods, and even now depends almost exclusively upon trigonometrical tracing of a few rays, which is, in fact, nothing else but trial and error. Probably this almost complete divorce between theory and practice accounts largely for the unprogressive character of pre-war British optical design as compared with the German.

(1) It is a natural inference that in some way the British type of text-book on this branch of science fails to stimulate the reader, and, bearing in mind the pioneer work of Abbe, Seidel, Steinheil, Koenig, and von Rohr in Germany, it is obviously desirable that the work of these masters of the subject should be made readily accessible to English-speaking students. The Department of Scientific and Industrial Research is therefore to be congratulated upon bringing out a translation of the classical treatise on "The Theory of Optical Instruments," edited by Moritz von Rohr. The translation has been carried out by Mr. R. Kanthack, and the work has evidently been done with great conscientiousness and accuracy. The translator acknowledges the valuable help of Messrs. J. W. French and E. B. Knobel and of Prof. J. W. Nicholson. In various respects the translation is an improvement on the original, the numbering of the paragraphs and equations greatly facilitating reference. Additions and modifications have also been made to the bibliography, and the figures have been improved and various errors corrected. The book is well got up, and altogether a very creditable production, which meets an undoubted need.

When all this has been said, however, it may be doubted whether, after all, von Rohr's treatise is really likely to stimulate the student, at any rate in this country. For one thing, it is not the work of a single mind. Chap. 1, on the fundamental principles, is by H. Siedentopf; chap. 3, on Abbe's theory of optical images, by E. Wandersleb; chap. 4, which treats of optical images from a different point of view, by P. Culmann; chap. 8, on prisms, by F. Loewe; Dr. Koenig has written chaps. 6 (on chromatic aberrations) and 7 (on the computation of optical systems in accordance with the theory of aberrations), the latter probably the most important of the whole book, from the point of view of the designer; von Rohr himself, although responsible for the editing of the entire collection, has actually written only chaps. 9 (on the theory of stops) and 10 (on the photometry of optical instruments); while he and Koenig are jointly responsible for chaps. 2 (on the computation of rays through an optical system) and 5 (on the theory of spherical aberration).

In the circumstances it is inevitable that there should be a certain lack of cohesion, which gives one the impression of a number of separate treatises bound together rather than of an ordered and progressive exposition.

To remedy this an attempt has been made to set up a rigorously uniform nomenclature throughout. A list of symbols is given at the end, but this list occupies six large pages of print, and the very sight of it seems likely to paralyse the reader. If symbols are to be standardised, then they should be as few and as fundamental as possible, so that they can be readily learnt and retained in the memory. This has the additional advantage of releasing a mass of symbols for use in special problems, where they may be usefully employed in simplifying the algebra.

Even with all these precautions the notation is not always clear; thus in formula (7), at the foot of p. 350, x' apparently refers (although this is not stated) to the intercept on the axis made by a principal image ray of a particular colour; but on the very next page x' is used to denote the intercept on the axis made by the image plane, and these two are not the same.

The suffix notation is based on refracting surfaces, quantities after refraction being accented. In many respects a notation which assigns odd suffixes to refracting surfaces (or to given combinations of them) and even suffixes to media is more convenient; it saves the use of accents, which are always confusing, making them available for other uses.

The main trouble, however, is that throughout the book the learner is not led up progressively from the easy to the difficult. Fundamental principles and results which must be grasped and remembered are not sufficiently extricated from a mass of detail which is best put on one side for reference if and when it is needed. Each chapter takes the reader to the limits of its particular domain, and leaves him there, somewhat bewildered at the multiplicity of results. What is really required in a mathematical subject of considerable algebraic complexity such as geometrical optics (or, say, theory of elasticity, or lunar theory) is a guiding thread, knotted at intervals into fundamental theorems. For such a guiding thread one looks in vain in von Rohr's treatise.

One notices, too, that characteristic tendency of most German works towards needless elaboration. Thus Fig. 15 and almost the whole of pp. 45 and 46 could be dispensed with by simply applying to the triangles BB_uO_u and BB_uO_u' in Fig. 14 the rule that the sides of a triangle are proportional to the sines of the opposite angles, which leads immediately to formula (6) of p. 46. Instead, we are given two pages of algebra, with several new symbols, including an auxiliary angle. This is only one of many examples.

On the other hand, the work is not free from the converse defect of introducing statements made on unconvincing grounds. Thus on p. 351 we are told that $V\beta=0$ when $s_k'=\infty$, because

$$\frac{Vs_k'}{s_k'-x_k'}=\frac{V\beta}{\beta}.$$

But in this case we have usually $\beta=\infty$ and $Vs_k'=\infty$, so a proof that $V\beta=0$ would involve a discussion of awkward indeterminate forms, of which nothing is said.

Such failures, however, are few. On the whole, the subject is treated with complete thoroughness, and the discussion is exhaustive, if laborious. von Rohr's theory of optical instruments is, and must remain, a classic and an admirable book of reference. But one must regretfully admit that the ideal book which is to fire the enthusiasm of the young British optical designer has still to be found.

(2) Far more attractive to the reader, and conceived in quite a different spirit, is another book by von Rohr, which appeared last year in Berlin, to wit, the second edition of his "Binocular Instruments." This is an eminently readable and interesting monograph dealing with the development of stereoscopic instruments, a branch of optical design in which German manufacturers had made very great progress before the war. The chapter dealing with the early investigations before the time of Wheatstone has been enlarged and rewritten.

The book opens with a chapter on the theory of stereoscopic vision, but the bulk of it is historical and descriptive, and the reader gradually builds up his knowledge of the subject by following the evolution of successive instruments. We would strongly recommend the study of this work to the British optical manufacturer. Its language is non-mathematical, and the geometrical arguments are easy to follow. The diagrams are not elaborate (probably on account of post-war conditions), but they are sufficient. The whole subject is one of great interest. Stereoscopic instruments have now got well beyond the curious toy stage, and have many applications of precision, not the least of which is to range-finders, of which the Germans appear to have made considerable use.

The value of such a historical monograph, especially with the excellent index of names and references at the end, is very great. To anyone desirous of acquiring rapidly knowledge of a subject for research purposes, it means an incredible saving of time and labour. It is also an aid to research in another way, by unearthing a number of results long forgotten, from which many a valuable hint can be gleaned. For the lack of work of this kind far too much of the time of men of science nowadays is spent on rediscovery. L. N. G. F.

Kite Balloons.

The Design and Stability of Streamline Kite Balloons, with Useful Tables, Aeronautical and Mechanical Formulae. By Capt. P. H. Sumner. Pp. viii+146. (London: Crosby Lockwood and Son, 1920.) 10*s.* 6*d.* net.

WHILE a vast literature has grown around aeroplanes since the outbreak of the war gave an unprecedented stimulus to aeronautical theory and practice, and a certain amount has been written about airships, very little indeed has seen the light of publication in connection with balloons. Popular interest was attracted to the more spectacular phases of flight; the Zeppelin raids dominated the minds of millions of non-combatants in the early part of the war, and the aeroplane raids captured their minds later on. To the active service man who was inclined to join the Air Force the aeroplane gave promise of excitement and distinction; to the scientific investigators at home the aeroplane and airship presented many problems of baffling difficulty and interest. The kite balloon, on the other hand, never reached such heights of popularity. Its work was more useful than spectacular; ever shrouded in secrecy, it scarcely ever attracted the attention of any who were not immediately engaged in its construction or its use.

A certain amount concerning the kite balloon is to be found in such a book as Bairstow's "Applied Aerodynamics," but it seems that Capt. Sumner's is the first separate book on the subject, at least in English. The author takes as model a balloon of capacity 670 cubic metres, which can rise to a height of 2500 ft. with one observer, and a suitable amount of ballast. By means of proportional rules other sizes can be readily calculated.

First the functions of the various parts of the kite balloon are explained, and then the aerodynamics are dealt with, leading up to the equilibrium problem. Longitudinal stability comes next, but the stability considered is statical, not dynamical; this ensures great simplification, of course, but something might have been said about the justification for using it. Chapters follow on the effect of the wind, tension in the material of the balloon, the valve, the envelope and rigging. There is, finally, a short account of meteorological balloons.

Much useful information is contained in the appendix, which is, however, rather miscellaneous in character. One wonders whether a man capable of following the reasoning in such a book needs an appendix containing the formula for the area of a circle or the definitions of the trigonometrical ratios. S. Brodetsky.

Our Bookshelf.

Airman's International Dictionary: Including the Most Important Technical Terms of Aircraft Construction, English, French, Italian, German. By Mario Mele Dander. Pp. vii+227. (London: Charles Griffin and Co., Ltd., n.d.) 6*s.*

Aviation for commercial purposes has failed to develop in the manner that was anticipated, yet several regular air services have come into existence, and if the evolution of civil aeronautics is slow, we can have no reason to doubt the ultimate emergence of the aeroplane and airship as standard means of locomotion. There is therefore complete justification for the assertion in the publishers' note that ". . . there is urgent need for a handy dictionary which will enable a flying man to make his needs and desires known in whatever country he may land." The dictionary was printed in Italy, and Messrs. Griffin have secured copies for issue in this country. It forms an eminently useful handbook, not only for the pilot, but also for the student and researcher, who often have to consult literature in foreign languages and deal with terms which are too recent for the standard dictionaries.

The dictionary gives the important technical terms in connection with aeroplanes and airships, as well as with aeroplane and airship construction. There is a "one alphabet" index for all four languages, thus saving much time in the search for the meaning of any term.

In a book of this kind mistakes and misprints are to be expected, and it is to be hoped that in a future edition experts in the various languages will be called in to revise the terms. Thus any

English worker in aeronautics would have been able to supply the usual terms for "frontal resistance," "end of climb," "gigantic plane," etc.

S. BRODETSKY.

Handbook of Instructions for Collectors. Fourth edition. Pp. 222. (London: The British Museum (Natural History), 1921.) 5*s.*

THE present edition of this valuable little handbook contains several material alterations. Chapters have been added on the preparation of mammalian skeletons, with special notes on the collection of specimens of Cetacea, on the collecting and preservation of worms, and on alcohol and alcoholometers; while the chapters dealing with soft-bodied and other invertebrates, birds, reptiles, batrachians, fishes, and insects have been considerably modified. The trustees of the British Museum are well advised in issuing the handbook at a low price and in portable form (it measures 7 in. × 5 in. × ½ in.), for it constitutes an authoritative manual of instructions on the collecting and preservation of all objects included under the comprehensive title of "natural history." The hunter of big game is told how to skin his "kills" and to preserve the pelt and skeleton to the best advantage; indeed, collectors of every kind receive instructions enabling them to render their captures of real scientific value when brought home for detailed examination. The handbook should lie on the work-table of the curator of every museum, and be in the kit-bag of everyone who is prepared during his travels to preserve objects for the enrichment of our national or other public collections. There are very few curators who will not learn something of value to their museum from these pages; and probably none who have not at one time or other been compelled regretfully to scrap material presented because the well-meaning donor has not known how to collect intelligently or to preserve usefully. In future there need be no such mistakes.

Sun, Sand, and Somals: Leaves from the Notebook of a District Commissioner in British Somaliland. By Major H. Rayne. Pp. 223+12 plates. (London: H. F. and G. Witherby, 1921.) 12*s.* 6*d.* net.

THE conversational style and highly amusing nature of Major Rayne's lively book by no means obscure the light that it throws on the Somali character, particularly that side of it which could be observed only by one occupying an official position similar to that of the author and largely concerned with the administration of justice and the settlement of disputes in the patriarchal fashion alone understood by the Somalis. No less interesting are the narrative portions. The description of the trek to Hargeisa is so vivid that the reader almost imagines himself one of the party. The chapter that recounts the end of the Mad Mullah illustrates the universal law of history, that when the means of force are dispelled the end of the tyrant is inevitable. An error of date has slipped into p. 214: it was at the beginning of April, 1903, that Col. Plunkett and his force were ambushed, leaving as survivors only thirty-eight natives of the K.A.R.; Gough's action was on April 22, about a fortnight later. Since those days much more has been learned about Somaliland and its inhabitants, and it may be that the use of the word "Somals" as a collective noun for the various tribes, though not to be found in Swayne's standard work, is the modern convention.

Geology of the Non-Metallic Mineral Deposits other than Silicates. Vol. 1, *Principles of Salt Deposition.* By Amadeus W. Grabau. Pp. xvi+435. (New York and London: McGraw-Hill Book Co., Inc., 1920.) 30*s.*

GEOLOGISTS owe a debt of gratitude to Dr. Grabau for the preparation and publication of this volume. It is a mine of information on the occurrence and characters of deposits of mineral salts, exclusive of silicates.

The theories which have been advanced for their formation are fairly stated, and there are ample references to the literature of the subject. The author includes in his survey not only the salts of the halogens, but sulphates, nitrates, and phosphates, as well as certain elements, oxides, and hydrates associated with them. He acknowledges the sea as the great source of salt deposits, but is inclined to give rather undue importance to the salt enclosed in marine sediments in comparison with that transported by the wind. He terms the former "connate" salts, and the latter, not very happily, "cyclic" salts. Salts due to chemical changes *in situ* are termed "meta" salts, in spite of the fact that chemists have used the prefix in more than one other distinct sense. Naturally special attention has been given to American deposits, but the other continents are not neglected, though we have been unable to find any reference to the important "Magadi" soda lakes in East Africa. An interesting account is given of the "salt domes" in different parts of the world.

J. W. E.

Bibliographie des Séries Trigonométriques: Avec un Appendice sur le Calcul des Variations. By Maurice Lecat. Pp. viii+168. (Louvain: M. Lecat, 1921.)

A VERY considerable debt is owing to M. Lecat not only for the labour which has been put into the compilation of this most valuable bibliography, but also for undertaking the publication of it without the help of any subvention, especially at so difficult a time. The main list is in alphabetical order according to authors, and gives full bibliographical details. It appears to be remarkably complete and up to date. A second list gives the titles of all the periodicals quoted in the first. An appendix provides a supplement to a similar bibliography on the calculus of variations (published 1913–16), and refers mainly to items which have appeared in the last five years. Those who specialise in the subject of trigonometric series will find M. Lecat's work invaluable.

South African Mammals: A Short Manual for the Use of Field Naturalists, Sportsmen, and Travellers. By A. Haagner. Pp. xx+248. (London: H. F. and G. Witherby; Capetown: T. Maskew Miller, 1920.) 20*s.* net.

THERE is no lack of works on the subject of African mammals. Some of them are of a purely sporting charactér; others appeal more particularly to the naturalist; Mr. Haagner's book on South African mammals claims to be a short manual for the use of field naturalists, sportsmen, and travellers.

No other country of equal size possesses so large and so varied a mammalian fauna as South Africa, and it is quite a feat to describe all the species occurring there in so short a compass, and to illustrate the text with more than 140 photographic reproductions. Some of the latter no doubt might, with advantage, have been omitted, as they give but a poor idea of the animals alluded to, and this would have left a little more room for the text. Many of the illustrations, however, are good, particularly those of the zebras.

The author, as he says in his introduction, has purposely adopted a more or less "note-book" style, and this has resulted sometimes in rather loose and inadequate descriptions. For example, all the information he can give us about the small grey mongoose is that it is a small edition of the grey mongoose, and about the same size as the slender mongoose. All naturalists must disapprove of the actions of what Mr. Haagner justly styles "game-butchers." It is therefore all the more surprising that he should reproduce as a frontispiece to his book a photograph of a heap of skulls, referred to as the hunting trophies of the "good old days."

As we should expect, the book appeals more directly to managers of zoological gardens and to dealers in livestock. The author's unsuccessful experiences in endeavouring to rear the young of Cape hunting-dogs are shared by many others. Only the Dublin Gardens have been more fortunate in their efforts, and have contrived to breed and rear the pups.

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.*]

Communism and Science.

IN view of the article on "The Proletarisation of Science in Russia" in NATURE of September 1, the following extracts from a letter I have just received from a well-known Russian professor of chemistry may be of interest. I have omitted personal references and a few other matters. J. W. MELLOR.

Pottery Laboratory, Stoke-on-Trent,
September 5.

"You doubtless know the old adage, 'Primo vivere, deinde philosophari.' I do this last, but the first part, 'vivere,' is more than uncertain for us who have the misfortune to be a little civilised, as one never knows what our wild, wild taskmasters are going to do next. The higher schools of Petrograd are under the control of a former apprentice of the dockyards of Cronstadt, who has learned to talk glibly and to sign his name with an appropriate flourish. He has not the remotest notions as to what is a seat of high learning; but that does not trouble him in the least, he just governs according to his lights, and actually does his best to destroy all culture, all real science, in our institutes. It is just the same everywhere, and the results are glaringly apparent in the utter failure of crops in the east and south of Russia, due not so much to exceptional climatic causes as to the countless requisitions of 'surplus' wheat, 'surplus' bullocks and horses, and other kindred measures of the reigning proletariat. The population of some twenty provinces, which supplied once upon a time almost all Russia with bread and exported thousands of tons of wheat to foreign lands, is now leaving their houses and fleeing to the east, the north, and the west of Russia, where there is still something to eat; they spread desolation wider and wider—also cholera and other diseases; tens of thousands perish daily. Almost nothing is left in the devastated provinces; they must now be colonised anew. We are fortunate for the nonce in being sufficiently far from these places, but the outlook for us is anything but reassuring.

"Up to now we receive a 'ration of scientists,' which during 1920 was comparatively good, but is now reduced to the following items, received, for instance, in June:—14 lb. of bread (made principally out of soya beans); 11 lb. of soya beans (it is not generally known that they contain poisonous constituents, and many were the cases of poisoning); 19 lb. of herrings; 4 lb. of tallow (the first fatty substance received since February); 9 lb. of wheat (we eat it boiled in the form of gruel); 3 lb. of macaroni made out of soya beans; 1 lb. of salt; 1¼ lb. of sugar; 3 lb. of lean pork—bones and hide, no lard, and very little meat; ¼ lb. of tea (surrogat); ¾ lb. of tobacco; some matches; and 1 lb. of washing soda (there is no soap). During the same month I received—only a few days ago—as salary for my lectures, etc., the stately sum of 21,000 roubles; but as bread costs about 4000 roubles and butter 30,000 roubles per lb., this sum is the equivalent of 5 lb. of bread, or some 20 kopeks (=5*d.*) of pre-war days. You will thus appreciate the munificence of my salary; the meanest mechanic or plumber gets from 250,000 to 500,000 roubles and more monthly, and it is nothing unusual to pay 1 lb. of bread or 5000 roubles for one hour of manual work, whereas I, as a full-fledged professor and doctor of chemistry, receive for one hour of lecture 450 roubles. Consequently, to nourish the members of the family (I have, fortunately, neither wife nor children, but live with my old mother), I work in kitchen-gardens, sell the few things that are still left, etc. The prices for a new suit range up to 1,000,000 roubles; a pair of old high boots, which I could not wear and which cost originally some fifteen years ago 14 roubles, fetches now 700,000 roubles, as boots are very scarce; for a shirt you get 2 lb. of butter. During the first six months of 1921 my mother and I have eaten different foods to the value of about 6,000,000 roubles.

"Needless to say that, in spite of these millions, we are now paupers in the strict sense of the word. All my savings, made little by little during more than twenty-five years of professorship, were placed in State loans and annulled in 1917; our small landed estate not far from Petrograd was taken from us in 1918, and is now completely devastated, all the woods having been cut. It would be now utterly impossible to exist without the 'ration of scientists,' meagre as it is. I read in NATURE in 1920 a notice on the voyage of Mr. Wells to Petrograd and his opinion on the position of our men of science (NATURE, vol. 106, p. 352). He did not see much, as he was 'personally conducted,' and does not understand Russian. He estimates the number of men of science at four thousand; NATURE expresses some astonishment at this number—thinks there must be less, as many have died. Well, there is here an official commission, composed of Mr. Oldenburg and other learned gentlemen, who decide whether an applicant is a man of science or not. As it is often a question of life and death, the decision is usually in favour of the applicant, if certain formalities are fulfilled—if he has printed some learned articles, or even simply written one, etc. Professors are almost always included if they teach in higher schools. There are now very many proletariat "higher institutes"; for instance, a "Higher Institute of Anti-fire Technique" and a "Higher Institute of Plastic Arts"; the first turns out firemen for fire brigades, the second—dancers! "Professors" of these institutes are also "scientists"! Even among the professors of old high schools there are now some without scientific degrees called "red professors"; for now it is decreed that anybody can be a professor, just as anybody who is sixteen years of age can be a student. If he is quite ignorant he will attend a "preparatory course," but, like real students, will receive his ration and salary (students do not *pay* anything now, but receive salaries).

"Thus the question, 'What is a man of science?' is not so simple as it seems. The number of men of science would certainly exceed the four thousand of Mr. Wells if the Soviet of deputy workers and deputy red soldiers did not happen to fix the number of rations at two thousand. Of course, all this is very detrimental to the interests of real scientific workers, whose number, I should think, does not exceed several hundred; the more so as it is officially announced that scientific workers of England, France, and the U.S.A. have formed committees to help us. It would be a good thing if some representatives of these committees could come and preside over the distribution. Last year the Norwegian Government sent us a lot of presents, but the precise amount sent was carefully kept in the dark, so that we have more than a suspicion that we received only a part of the alms—and then only some coarser things, like herrings and cod—and that the dainties were taken by other parties for whom they were not intended.

"You see I write as a matter of course about receiving alms; we have long ago lost all sense of pride—beggars cannot be choosers—and we can only thankfully accept foreign help. As I express myself easily in English I could not resist the temptation to give to you just a very small epitome of what is meant by 'vivere' for us, but there are many other not very agreeable things which I cannot mention now. In spite of them, the habits of twenty-five years cannot be given up, and I still interest myself in the process of chemistry. . . .

"I have read over what I have written on the subject of 'primo vivere, deinde philosophari,' and see that there is enough unintentional humour about it—but there is precious little humour in living it through."

The Disaster to the Airship R38.

IN the article on "The Disaster to the Airship R38" in NATURE of September 1, the author laments that, in consequence of it, airship development is to be abandoned by our Government, and airship design is referred to as being a matter of experience and guessing. In face of the general tenor of the article, it may be of interest to direct attention to six letters published in *Engineering* in November and December, 1901, which I wrote in a discussion of the torpedo-boat destroyer *Cobra*. Those letters are as applicable to the R38 as to the *Cobra*.

Some eminent scientific men then denied the possibility of the disaster to the *Cobra* being due to gyroscopic action of the propeller and engines; and the first of my letters was written merely to insist on the existence of such action, though I declared that I could not consider it sufficient to account for such an accident. The course of the discussion, however, led me to declare it to have been the sole cause of the disaster.

The important point is that all then existing destroyers had engines fitted into them after the ship had been built. I pointed out that such engines should be built with the bearings as an intrinsic part of the engines and extending the full length and breadth of the ship, and also strong enough to resist any force that could be exerted by the engines. I considered that a vessel and engines so constructed would not only be safer, but might also be lighter than one dependent on heavy plates and girders for strength to stand the stresses created by pitching and rolling.

By giving the airship's engines such bearings as above suggested it may be made safe against any such accident as that which has wrecked the R38.

The old destroyers offered, perhaps, more scope for saving weight than the airship, but by giving such bearings to the engines as above suggested at least three-fourths of the present weight of girders might be dispensed with. WM. LEIGHTON JORDAN.

Royal Societies Club, September 3.

BEFORE dealing with the main contention of Dr. W. Leighton Jordan's remarks on the loss of R38, it is desirable to refer to the opening paragraph and to correct the impression that, "in consequence of it, airship development is to be abandoned by our Government." The policy of the Air Ministry was determined and announced many months before the accident, and therefore cannot have been influenced by the failure of R38. The campaign for economy in the public service, combined with a lack of enthusiasm on the part of the Air Council, is much more likely to be the explanation of the decision to abandon airships.

Dr. Jordan appears to attach much importance to gyroscopic action in relation to the breaking of R38. Such action is called into play when the airship turns, and, as is well known, the magnitude of the couple is proportional to the rate of turning of the ship. There is little difficulty in estimating the magnitudes of the forces to be resisted, and, since an airship turns slowly, in seeing that they are relatively small. It is not usual for engineering structures to fail against well known loads, and there is no reason to suppose that R38 is an exception. It is rather to those unknown effects supposed to be covered by a "factor of safety" that attention is drawn by failure. The less the scientific and technical preparation for construction, the greater the call on the allowance for ignorance. The scientific objection to full-scale tests to destruction is not to their effectiveness, but to their cost in life and material; they are, in fact, the result of false economy.

THE WRITER OF THE ARTICLE.

The British Association at Edinburgh.

A RETROSPECT.

FROM every point of view the visit of the British Association to Edinburgh has been an unqualified success. With the exception of the last day of the meeting the weather was highly favourable; and even on that day the rain was confined to the early forenoon hours. Every morning the reception room, the old Parliament Hall, was crowded with members whose eager happy looks showed that they were enjoying the meetings to the full. The citizens of Edinburgh gave themselves up to the spirit of scientific gaiety, and the visitors heartily responded. Every section had its own devoted band of disciples; and what specially impressed those who remembered the last Edinburgh meeting in 1892 was the proportionately greater number of women members. This, of course, added a brilliancy to the gatherings, particularly when two or more sections met for a common discussion.

These common discussions formed indeed one of the distinctive features of the Edinburgh meeting: physicists and chemists together inquiring into the structure of molecules; physicists, geologists, and biologists comparing views on the age of the earth; chemists and physiologists solving the mysteries of biochemistry; botanists and geologists discussing in lively fashion the oldest land flora; geographers and anthropologists striving to discover the origin of the Scottish people; geologists and engineers trying to come to an agreement on the Mid-Scotland canal; and so on in other cases. The popularity of these combined discussions was demonstrated by the crowded attendances which strained to the very utmost the accommodation provided by the largest classrooms of the university.

Fortunately for the presidential address and the various evening lectures and addresses splendid accommodation was afforded by the Usher Hall, which was completed just before the outbreak of the war. Owing to his regrettable illness Sir Edward Thorpe was unable to deliver his address in person, and it was not until the last day but one of the meeting that the members of the Association were able to rejoice in the presence of their president. The citizens of Edinburgh took full advantage of the special lectures prepared for them. Sir Oliver Lodge discoursed with his well known ease and lucidity on "The Principles of Wireless Telephony"; Prof. Dendy delighted a large audience with a finely-planned lecture on "The Stream of Life," and Prof. Fleure gave a suggestive and highly interesting disquisition on countries as personalities, in which special prominence was given to Scotland. The two evening discourses given to the members of the Association were both of great local interest, one being a comparison of the Forth and Quebec Bridges, by Prof. C. E. Inglis, O.B.E., and the other on "Edinburgh and Oceanography," by Prof. Herdman, C.B.E., F.R.S. Both lectures were profusely illustrated by lantern slides, and were greatly appreciated by large audiences.

The great reception given by the Lord Provost was held, as usual, in the Royal Scottish Museum, the large hall and galleries of which formed an appropriate setting for this large and brilliant gathering. Huge though the assembly was in point of numbers, there was no uncomfortable crowding. Endless streams of friendly groups meandered through the treasures of art and science in the various halls and along the great galleries from which a bird's eye view could be obtained of the ever shifting scene below. Music added to the charm, provided the listener was not too near, when conversation became almost impossible. It is doubtful if there exists a finer place for a reception than a building of the nature of the Royal Scottish Museum, where even the solitary wanderer can find interest in the varied contents of the cases displayed to view.

The excursions arranged by the local committee were well patronised, the most popular perhaps being that to Rosyth and Hopetoun House, where the visitors were received and entertained by the Marquess of Linlithgow, and the visit to Dunfermline, on the invitation of the Carnegie Trustees. The long excursions to the Scott country and to the Trossachs also attracted many sightseers. Unfortunately those who visited the West encountered heavy rains; and one section of the party was driven the wrong way, thereby missing the stage at which lunch was provided, and returning home hungry and miserable after a twelve hours' fast. Particularly interesting also were the small excursions arranged for Old Edinburgh, for Swanston, the early home of R. L. Stevenson, and for other interesting places in the immediate vicinity. The garden party given by the local committee was, in a certain sense, an excursion to the finely appointed Zoological Park. This was on the Tuesday afternoon just as the weather became somewhat threatening. Fortunately the rain held off until the evening, and the members thoroughly enjoyed their visit to a park the natural beauties of which have been skilfully adapted to the needs of all types of wild animals.

The Senatus of the University of Edinburgh took advantage of the presence of the British Association to confer the honorary degree of Doctor of Laws on nine of the eminent strangers visiting the city. These were Sir Edward Thorpe, the President of the Association; Prof. Arrhenius, Director of the Physico-Chemical Department of the Nobel Institute, Stockholm; Prof. Kapteyn, of Groningen, the discoverer of the two star streams; Prof. Krogh, the eminent physiologist of Copenhagen and Nobel Laureate; Dr. Irving Langmuir, Schenectady, New York, well known for his electrical work and his investigations into the structure of atoms; Sir Oliver Lodge, probably the best known man of science in our midst; Sir William Ridgeway, Professor of Archæology at Cambridge; Professor Vito Volterra, one of the foremost mathematicians of the day; and Prof. R. W. Wood, of Johns Hopkins University, Baltimore, famous for his brilliant experimental researches in optics. These outstanding representatives of science in its various branches were presented to the Vice-Chancellor, Sir Alfred Ewing, by Prof. Whittaker (acting for the Dean of the Faculty of Law), who hit off the characteristic work of each in the happiest phrasing.

Another side issue of the British Association meeting was the Royal Societies' dinner, at which the fellows of the Royal Societies of Edinburgh entertained as their guests the fellows of the Royal Society of London, the members of the Royal Irish Academy, and eminent foreign visitors to the meeting. The Maharaj Rana of Jhalawar was also a guest. This brilliant function was held in the Masonic Hall, probably the most artistic hall in Edinburgh. Nearly two hundred were present, and the guests and hosts were arranged in such a way that those representative of any one science formed a group at one of the tables. The toasts were proposed and responded to by speakers selected on a broad international basis, and the speeches were short, congratulatory, breezy, and humorous. One point referred to by Sir James Dewar is worth chronicling on account of its historic interest, and might have found a place in the handbook "Edinburgh's Place in Scientific Progress." Some seventy-five years ago a young extra-mural teacher, Dr. Samuel M. Brown, gave four lectures on the atomic theory and, to a large intellectual audience packed into his lecture room, broached ideas regarding the complicated nature of atomic structure which were far in advance of his day, and closely approximated to the ideas now so prevalent. Samuel Brown died at the age of thirty-nine, and Edinburgh lost a brilliant son who, had he lived, would have brought renown to his city.

For one glorious week the people of Edinburgh rejoiced in the British Association—just as profoundly as the visiting members of the Association rejoiced in Edinburgh. There was exhilaration in the very air, and the profoundest problems were tackled in a cheerful spirit. Two thousand seven hundred and sixty-eight members drawn together from all parts of the world shared in this intellectual feast of good things, the golden memories of which will be a life-long possession.

C. G. K.

Science and Crop Production.[1]

By E. J. RUSSELL, D.Sc., F.R.S., Director of the Rothamsted Experimental Station.

THE beginning of much of our scientific work on crop production goes back to the year 1843, when Lawes and Gilbert set out to discover why farmyard manure is such an excellent fertiliser. Two opposing explanations were offered by the chemists of the day; the older view, coming down from the eighteenth century, was that the fertilising value lay in the organic matter; the newer view put forward by Liebig in 1840 was that it lay in the ash constituents—the potash, phosphates, etc.—left after the manure is burnt. Lawes and Gilbert considered that it lay in the ash constituents *plus* the nitrogen of the organic matter, and they devised a critical field experiment to decide the matter. They divided a field of wheat into plots of equal size, of which one received farmyard manure at the rate of 14 tons per acre, another received the ashes of exactly the same dressing of farmyard manure, a third received the mineral matter of the ashes *plus* some of the combined nitrogen that had been dissipated on burning, and a fourth lay unmanured. The results were very striking:—

Broadbalk Wheat Field, 1843.

	Grain. Tons per acre.	Straw. Cwts. per acre.
Farmyard manure	22	13
No manure	16	10
Ashes of farmyard manure ..	16	10
Mineral matter of ash *plus* sulphate of ammonia to supply combined nitrogen	26¼	15¾

[1] Abstract of a farmers' lecture of the British Association delivered at Edinburgh on September 7.

The ashes proved ineffective, but the ashes *plus* the combined nitrogen acted just as well as farmyard manure; it is therefore these that constitute the fertilising constituents of the manure. Thus the old controversy was decided in a way not uncommon in science; neither side proved to be entirely correct, but both sides were found to have some basis of truth. Lawes and Gilbert did not rest content with this purely judicial and scientific conclusion; they saw that they could make up this effective mixture of ashes and combined nitrogen from mineral substances without using farmyard manure. Even in their day farmers were unable to obtain sufficient farmyard manure, and it was therefore a great achievement to be able to supplement the limited supplies by this mixture. A factory was set up, and the manufacture of the so-called artificial fertilisers began. Subsequent experience showed that the ash constituents are not all equally necessary; in practice only two of them, potash and phosphates, need be supplied in addition to nitrogen.

Chemists are rightly proud of artificial fertilisers, for they have proved extraordinarily successful in augmenting crop production all over the world. The demand for them is enormous, and in consequence prices have risen considerably within the last thirty years. Agricultural chemists are always looking out for new substances, and even during the war a new fertiliser, ammonium chloride, was added to the list and new plant has been erected for its manufacture. Modern manufacturing facilities are, perhaps, adequate for present demands, but it is certain that much more fertiliser could be used, and that as farming improves the demand will increase.

Progressive farmers have long passed the stage when it was necessary to demonstrate that artificial manures increase crop production; the position now is the much more difficult one of deciding how much money it is wise to spend on fertilisers. The old view was that the crop yield was proportional to the manurial dressing—*i.e.* that the more the manure the bigger the crop. Lawes and Gilbert showed this was not altogether correct, and that the yield fell off after a certain sized dressing was reached; this relationship is expressed by a straight line which ultimately becomes a curve. A later view set up by Mitscherlich was that the effect of the manure is propor-

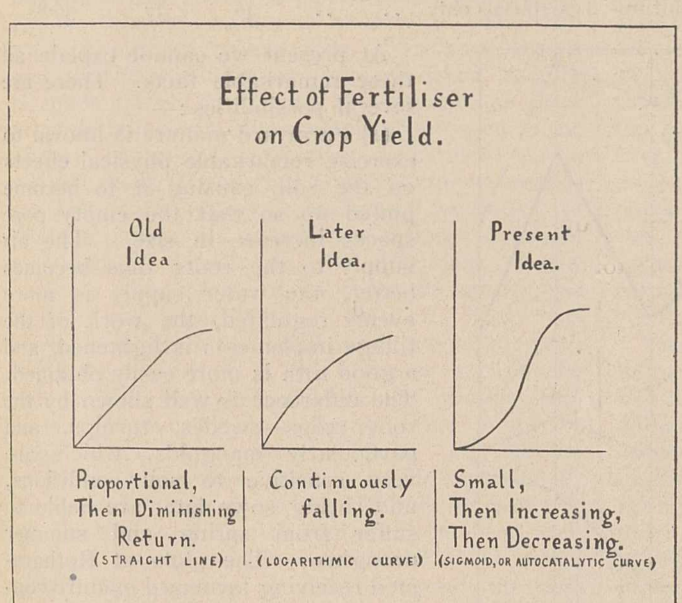

FIG. 1.—Curves showing relationship between crop yield (plotted on vertical axis) and quantity of fertiliser used (plotted on horizontal axis).

tional to the decrement from the maximum obtainable; that therefore the first dose of manure has a large effect; but that further doses have progressively less action. This relationship is expressed by a logarithmic curve. The present view is that the effect is at first small; then it increases and then decreases; this relationship is expressible by a curve resembling that for autocatalysis. The important practical consequence is that moderate dressings are more profitable than small ones, but they are also more profitable than much larger ones (Fig. 1). There is no difficulty about the general rule; the difficulty arises when one tries to define a moderate dressing. The problem is further complicated by the fact that the effect of the dressing is greatly influenced by the time when it is put on to the land. In our own case the results have been as follows :—

	Increased yield of grain. Bushels per acre.			Increased yield of straw. Cwts. per acre.		
Date of application of manure	Feb. 10	Mar. 6	May 10	Feb. 10	Mar. 6	May 10
Single Dressing ..	Nil.	0·9	2·7	2·7	6·9	9·4
Double Dressing ..	7·0	—	3·7	11·7	—	12·7

This experiment ought to be repeated in many districts, for it is by no means certain that farmers generally are using the most profitable quantities of fertiliser at the most effective time. It is, however, necessary to take into account something more than the quantity and the time of application of the fertiliser. It is essential also to have a suitable mixture. In the old days this question was thought to be fairly simple. Chemists used to think that if they knew the composition of the ash of plants they would know what manure to use; it should supply all the ash constituents in the quantities present in the plant. This is now known to be wrong; the composition of the ash affords no guidance to manurial requirements, as was, indeed, shown by Lawes and Gilbert in 1847. The distinguished French chemist, Georges Ville, emphasised the fact that only properly conducted field trials would ever settle the question. Vast numbers of such experiments have been made, and they show that the problem is more complex than Ville thought. It is now known that no single formula expresses the fertiliser needs of a crop; every district, almost every farm, has its own special requirements.

Still further difficulty is introduced by the fact that the various artificial fertilisers not only increase crop yields, but also influence the composition and habit of growth of the crop. Nitrogenous manures tend to a vegetative growth of large, deep-green leaves which are somewhat liable to be attacked by fungoid pests. Phosphates improve root development, and are therefore of special value for swedes and turnips; they also hasten ripening of grain, and are therefore particularly useful in late districts; they increase the feeding value of crops, and are therefore useful for fodder crops; and they have a remarkable effect on the development of clover, which is not yet fully understood, but which has revolutionised the treatment of pastures in this country. Potassic fertilisers improve the vigour of the plant and increase its power to resist fungus attacks. These and other special properties of fertilisers are now well established, and advantage is taken of them in drawing up fertiliser schemes to suit the special requirements of each farm.

It has already been pointed out that this work on artificial fertilisers arose out of Lawes and Gilbert's discovery that the wheat crop of 1843 grew just as well when supplied with the ash constituents *plus* combined nitrogen as when supplied with farmyard manure. They repeated the experiment year after year; periodically the results were collected, and even after fifty years on an average the artificials had done as well as the farmyard manure. In consequence of this and other experiments many agricultural chemists developed the view that artificial manures were at least as good as farmyard manure for ordinary use on the farm; but wider knowledge has shown that this is not the case; it is only a first approximation to say that artificial fertilisers are equally as good as farmyard manure; we now know that farmyard manure produces effects of the highest importance to the land which no known combination of artificial fertilisers will bring about.

Examination of the Broadbalk data in the statistical laboratory recently instituted at Rothamsted under Mr. R. A. Fisher shows that farmyard manure differs in two ways from artificials —the variation in yield from year to year is diminished by the use of farmyard manure, as is also the deterioration in fertility due to continuous cropping for eighty years. No fewer than fifteen different combinations of fertilisers are tested against farmyard manure, and while some of them come out quite well on an average of twenty-five or fifty years, they fluctuate considerably from season to season, and they show manifest signs of deterioration as the years pass by. Many farmers prefer a steady yield to a fluctuating one, and this, of course, is sound, cautious business. Farmyard manure never does badly even in the worst seasons, but, on the other hand, it does not give record crops even in the best seasons. What we should like would be something possessing the special values of farmyard manure in bad seasons, and of artificials in good ones.

Further, there is a deterioration of yield on all our plots treated with artificials excepting perhaps those receiving exceptionally high dressings. This is shown on both the wheat and the barley plots, and it is greatest on those plots where one of the essential fertiliser constituents is withheld (Fig. 2).

There is a third effect, which is very marked in rotations. Farmyard manure appears to have a greater effect than artificials in increasing the growth of clover. Unfortunately the number of experiments is not very great, but, so far as they go, they show a striking superiority over artificials, and this extends not only to the clover, but also to the succeeding wheat crop.

The results at Rothamsted are:—

Manure applied to previous corn crop.	Yield of clover hay. Cwts. per acre.	Yield of succeeding wheat crop. Grain. Bushels per acre.	Straw. Cwts. per acre.
Farmyard Manure ..	62	45	45·3
Artificials only	46	37	36·8

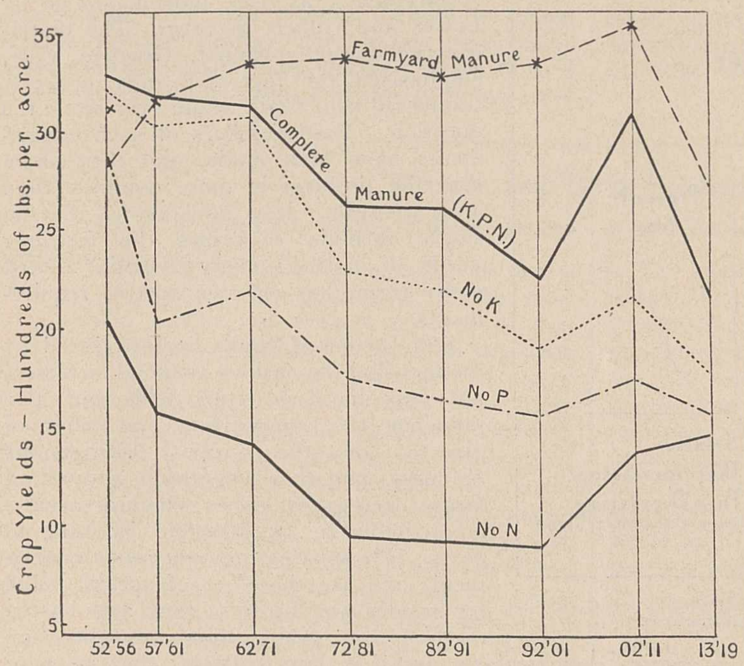

FIG. 2.—Effect of fertilisers on yield of barley. (Horsfield, Rothamsted, 1852–1919.)

At present we cannot explain all these remarkable facts. There are several possibilities:—

(1) Farmyard manure is known to exercise remarkable physical effects on the soil, causing it to become puffed up so that the empty pore spaces increase in size. The air supply to the roots thus becomes better, the water supply is more evenly regulated, the work of the tillage implements is lightened, and a good tilth is more easily obtained. The difference is well shown by the root crops—swedes, turnips, and particularly mangolds, which are very sensitive to soil conditions, and, being sown late, are liable to suffer from spring and summer droughts. The plots at Rothamsted receiving farmyard manure contain always some 2–5 per cent. more moisture than those receiving no manure or artificials only, and this enables the mangolds to keep growing during a drought which effectually checks all plants not receiving farmyard manure.

(2) It is possible that there are chemical constituents in farmyard manure which are not present in our artificial fertilisers. The old idea that nitrates, potash, and phosphates only are necessary may be wrong. Recent work by Mazé in Paris and by Dr. Winifred Brenchley at Rothamsted show that some of the other elements may also be helpful. In the Rothamsted experiments very small quantities of boric acid added to the soil caused distinct increases in crops fully fertilised with artificial manures. We cannot as yet recommend farmers to adopt this kind of manuring with special substances, because it is very easy to overstep limits and do much damage to the crop, for the plant suffers seriously from even slight excess. With fuller knowledge, how-

ever, it may prove possible to keep this special manuring within bounds.

(3) In the case of the clover crop the farmyard manure or the straw in the litter may have a special effect on the organisms living in the root, causing them to increase the amount of nitrogen fixation and thus give larger clover crops and further enrich the soil in nitrogenous organic matter.

Work on these problems is progressing; the scientific investigator has, of course, to find out exactly what is happening before he can show the practical man how to exercise control.

But in the meantime it is necessary for us to be practical and to do something, and the most obvious line of action is to increase the amount of farmyard manure or similar substances on the farm. We can proceed in two ways; first, wastage can be cut down. We estimate that the farmers of the United Kingdom make about forty million tons of farmyard manure a year, and waste about ten million tons. We have shown that the best results are obtained when manure is made under cover and the amount of litter properly adjusted to the amount of nitrogen in the animal excretions. Correct adjustment is a counsel of perfection, but a great improvement is possible over the present haphazard methods. In practice nitrogen is always lost through exposure to weather, greatly to the detriment of the manure. The provision of some shelter for the heap is not difficult, and, as Prof. Berry has shown at Glasgow, it is distinctly advantageous.

Another method is to increase greatly the amount of farmyard manure or similar substances produced on the farm. This could be done by running on more animals. The number of livestock per acre could be much increased by the general adoption of the methods of some of the Scottish and Danish farmers, who keep their animals largely on the produce of their arable land. The problem is closely bound up with financial considerations, but the experiments of Mr. J. C. Brown at the Harper Adams Agricultural College show that more profit is obtainable from the soiling system than from the older methods of the south.

At Rothamsted we are examining possible substitutes for farmyard manure, green manuring, and the activated sludge method of producing manure from sewage, both of which seem quite promising. We tried using straw as manure, but without success; so soon, however, as the straw was rotted, much more promising results were obtained. The conditions for the proper rotting of straw, investigated at Rothamsted by Dr. H. B. Hutchinson and Mr. E. H. Richards, were found to be proper air and moisture supply, suitable temperature, freedom from acidity, and the proper proportion of soluble nitrogen compounds. All these conditions are easily obtainable on the farm, and it is now possible to make an artificial farmyard manure from straw without the intervention of animals. So far the results seem quite satisfactory. Arrangements are being made for demonstrations on an extensive scale during the present season.

All these problems I have been discussing represent work of interest to the present generation of farmers; but the scientific investigator cannot be restricted to problems of present-day interest. Some of the best work of to-day may never reach the farmer in our time, and, indeed, unless it is developed, it will never reach the farm at all. We now know that the farmyard manure and the green manure put into the soil are not really agents of fertility, but only raw materials out of which fertility is manufactured. The work is done by myriads of living creatures in the soil, which are too small to be seen by the naked eye, and only incompletely revealed even by powerful microscopes. Some of them are useful to the farmer and some not, many of them taking their toll of the valuable plant food in the soil. Their activity fluctuates daily, almost hourly, and their numbers are counted and their work is watched in our laboratories. Much of their activity is helpful to the farmer; it makes nitrates, indispensable for the growth of plants. Much of their time, however, is spent in undoing the good work they have done, and results in the destruction of a large proportion of the nitrates made. We are studying this population, and with fuller knowledge we hope to control it and make it serve the farmer just as horses, sheep, and cattle do; but we are a long way from that yet.

Finally an attack is being made on a much more difficult problem. The growth of a crop is like the movement of a motor-car; it cannot go on without a continuous supply of energy. In the case of the car the energy comes from the petrol; in the case of the growing crop it comes from sunlight. The plant as we grow it, however, is not a very efficient transformer; a crop of wheat utilises only about half of 1 per cent. of the energy that reaches it. During the last eighty years the growth of crops has been improved, thus increasing their efficiency as utilisers of energy; but we are still a very long way from the 30 per cent. efficiency which the motor engineer has attained. Better developments of our present methods will no doubt carry us further than we have yet gone, but some wholly fresh ideas are necessary before we can hope to bridge the enormous gap that now exists between the actual and what is theoretically possible. There seem to be at least six ways in which we might improve crop production:—

(1) We can hope for further improvements by the use of new varieties capable of making better growth than those ordinarily cultivated. Plant breeders all over the world are attacking this problem with much success, and many of the new sorts show considerable promise.

(2) Much can be done by control of plant diseases. Unfortunately we have no means of knowing how much is lost each year by pests or disease, but it is undoubtedly considerable. Laboratories for studying plant pathology have

been set up at Rothamsted and elsewhere, and we are hoping to achieve good results; much valuable information has already been obtained.

(3) We are also looking to the tractor to achieve great things on the farm. It will allow considerable development of cultivation implements, enable us to improve our tillage and to keep down weeds, a very serious trouble in the southern part of England. Good Scottish farmers in that region have told me that farming in Scotland is much easier than in England, because the rigorous northern winters keep weeds in check, while the mild southern winters encourage their growth.

(4) It is possible that certain substances, such as boric acid, the fluorides, etc., studied by Gautier and Claussmann in France, may help in raising crop growth.

(5) It is possible also that special methods may prove of value, such as the high-tension discharge tested by Miss Dudgeon at Lincluden, Dumfries, and ably and critically studied by Prof. V. H. Blackman.

(6) Finally, it seems probable that some wholly new method may be found for increasing crop growth. In most civilised countries there are now research institutes where the ways of plants and the properties of soils are being studied. Men of science, as a rule, do not care to risk prophecies or to attempt to create sensations, and I certainly am not going to break this wholesome rule. Something, however, has already been done; in spite of the decreased labour spent on cultivation, the yields tend to go up, while the new knowledge that is now being gained is adding greatly to the pleasure of farming and giving both masters and men an interest in their work that they never had before.

Applied Geography.[1]

By D. G. HOGARTH, M.A., D.Litt., C.M.G.

THE term "applied geography" has been in use for some years as a general designation of lendings or borrowings of geographical results, whether by a geographer who applies the material of his own science to another, or by a geologist or a meteorologist, or again an ethnologist or historian, who borrows of the geographer. Whether geography makes the loan of her own motion or not, the interest in view, as it seems to me, is primarily that, not of geography, but of another science or study.

Such applications are of the highest interest and value as studies, and, still more, as means of education. As studies, not merely are they links between sciences, but they tend to become new subjects of research, and to develop with time into independent sciences. As means of education they are used more generally, and prove themselves of higher potency than the pure sciences from which or to which, respectively, the loans are effected. But, in my view, geography, thus applied, passes, in the process of application, into a foreign province and under another control. It is most proper, as well as most profitable, for a geographer to work in that foreign field; but, while he stays in it, he is, in military parlance, seconded.

Logical as this view appears to me, and often as, in fact, it has been stated or implied by others (for example, by one at least of my predecessors in this chair, Sir Charles Close, who delivered his presidential address to the section at the Portsmouth meeting in 1911), it does not square with some conceptions of geography put forward by high authorities of recent years. These represent differently the status of some of the studies, into which, as I maintain, geography enters as a secondary element. In particular, there is a school, represented in this country and more strongly in America, which claims for geography what, in my view, is an historical or ethnological or even psychological study, using geographical data towards the solution of problems in its own field; and some even consider this not merely a function of true geography, but its principal function now and for the future. Their "new geography" is and is to be the study of "human response to land-forms." This is an extreme American statement; but the same idea is instinct in such utterances, more sober and guarded, as that of a great geographer, Dr. H. R. Mill, to the effect that the *ultimate* problem of geography is "the demonstrative and quantitative proof of the control exercised by the earth's crust on the mental processes of its inhabitants." Dr. Mill is too profound a man of science not to guard himself, by that saving word "ultimate," from such retorts as Prof. Ellsworth Huntington, of Yale, has offered to the extreme American statement. If, the latter argued, geography is actually the study of the human response to land-forms, then, as a science, it is in its infancy, or, rather, it has returned to a second childhood; for it has scarcely begun to collect exact data to this particular end, or to treat them statistically, or to apply to them the methods of isolation that exact science demands. In this country geographers are less inclined to interpret "new geography" on such revolutionary lines; but one suspects a tendency towards the American view in both their principles and their practice—in their choice of lines of inquiry or research and their choice of subjects for education. The concentration on man, which characterises geographical teaching in the University of London, and the almost exclusive attention paid to economic geography in the geographical curricula of some other British universities tend in that direction.

[1] Abridged from the presidential address delivered to Section E (Geography) of the British Association at Edinburgh on September 8.

In educational practice this bias does good, rather than harm, if the geographer bears in mind that geography proper has only one function to perform in regard to man—namely, to investigate, account for, and state his distribution over terrestrial space—and that this function cannot be performed to any good purpose except upon a basis of physical geography—that is, on knowledge of the disposition and relation of the earth's physical features so far as ascertained to date. To deal with the effect of man's distribution on his mental processes or political and economic action is to deal with him geographically, indeed, but by applications of geography to psychology, to history, to sociology, to ethnology, and to economics, for the ends of these sciences; though the interests of geography may be, and often are, well served in the process by reflection of light on its own problems of distribution. If in instruction, as distinct from research, the geographer, realising that, when he introduces these subjects to his pupils, he will be teaching them not geography, but another science with the help of geography, insists on their having been grounded previously or elsewhere in what he is to apply—namely, the facts of physical distribution—all will be well. The application will be a sound step forward in education, more potent perhaps for training general intelligence than the teaching of pure geography at the earlier stage, because making a wider and more compelling appeal to imaginative interest and pointing the adolescent mind to a more complicated field of thought. But if geography is applied to instruction in other sciences without the recipients having learned what it is in itself, then all will be wrong. The teacher will talk a language not understood, and the value of what he is applying cannot be appreciated by the pupils.

It will be patent enough by now that I am maintaining geography proper to be the study of the spatial distribution of all features on the surface of the earth. My view is, of course, neither novel nor rare. Almost all who of late years have discussed the scope of geography have agreed that distribution is of its essence. Among the most recent exponents of that view have been two directors of the Oxford school, Sir Halford Mackinder and Prof. Herbertson. When, however, I add that the study of distribution, rightly understood, is the whole essential function of geography, I part company with the theory of some of my predecessors and contemporaries, and the practice of more. But our divergence will be found to be not serious; for not only do I mean a great deal by the study of distribution—quite enough for the function of any one science!—but also I claim for geography to the exclusion of any other science all study of spatial distribution on the earth's surface. This study has been its well recognised function ever since a science of that name has come to be restricted to the features of the terrestrial surface—that is, ever since "geography" in the eighteenth century had to abandon to its child geology the study of what lies below that surface even as earlier it had abandoned the study of the firmament to an elder child, astronomy. Though geography has borne other children since, who have grown to independent scientific life, none of these has robbed her of that one immemorial function. On the contrary, they call upon her to exercise it still on their behalf.

Let no one suppose that I mean by this study and this function merely what Prof. Herbertson so indignantly repudiated for an adequate content of his science—physiography *plus* descriptive topography. Geography includes these things, of course, but she embraces also all investigation both of the actual distribution of the earth's superficial features and of the causes of the distribution, the last a profound and intricate subject towards the solution of which she has to summon assistance from many other sciences and studies. She includes, further, in her field, for the accurate statement of actual distribution, all the processes of survey—a highly specialised function to the due performance of which other sciences again lend indispensable aid; and, also, for the diagrammatic presentation of synthetised results for practical use, the equally highly specialised processes of cartography. That seems to me an ample field, with more than sufficient variety of expert functions, for any one science.

I have claimed for the geographer's proper field the study of the causation of distribution. I am aware that this claim has been, and is, denied to geography by some students of the sciences which he necessarily calls to his help. But if a science is to be denied access to the fields of other sciences unless it take service under them, what science shall be saved? I admit, however, that some disputes can scarcely be avoided, where respective boundaries are not yet well delimited. Better delimitation is called for in the interest of geography, because lack of definition, causing doubts and questions about her scope, confuses the distinction between the science and its application. The doubts are not really symptoms of anything wrong with geography, but, since they may suggest to the popular mind that in fact something is wrong, they can be causes of disease. Their constant genesis is to be found in the history of a science the scope of which has not always been the same, but has contracted during the course of ages in certain directions while expanding in others. If, in the third century B.C., Eratosthenes had been asked what he meant by geography, he would have replied, the science of all the physical environment of man whether above, upon, or below the surface of the earth, as well as of man himself as a physical entity. He would have claimed for its field what lies between the farthest star and the heart of our globe, and the nature and relation of everything composing the universe. Geography, in fact, was then not only the whole of natural science, as we understand the term, but also everything to which another term, ethnology, might now be stretched at its very widest.

Look forward now across two thousand years to the end of the eighteenth century A.D. Geography has long become a mother. She has conceived and borne astronomy, chemistry, botany, zoology, and many more children, of whom about the youngest is geology. They have all existences separate from hers and stand on their own feet, but they preserve a filial connection with her and depend still on their mother science for a certain common service, while taking off her hands other services she once performed. Restricting the scope of her activities, they have set her free to develop new ones. In doing this she will conceive again and again and bear yet other children during the century to follow—meteorology, climatology, oceanography, ethnology, anthropology, and more. Again, and still more narrowly, this new brood will limit the mother's scope; but ever and ever fecund, she will find fresh activities in the vast field of earth knowledge, and once and again conceive anew. The latest child that she has borne and seen stand erect is geodesy; and she has not done with conceiving.

Ever losing sections of her original field and functions, ever adding new sections to them, geography can scarcely help suggesting doubts to others and even to herself. There must always be a certain indefiniteness about a field on the edges of which fresh specialisms are for ever developing towards a point at which they will break away to grow alone into new sciences. The mother holds on awhile to the child, sharing its activities, loth to let go, perhaps even a little jealous of its growing independence. It has not been easy to say at any given moment where geography's functions have ended and those of, say, geology or ethnology have begun. Moreover, it is inevitably asked about this fissiparous science from which function after function has detached itself to lead a life apart—what, if the process continues, as it shows every sign of doing, will be left to geography? Will it not be split up among divers specialisms, and become in time a venerable memory? It is a natural, perhaps a necessary, question. But what is wholly unnecessary is that any answer should be returned which implies a doubt that geography has a field of research and study essentially hers yesterday, to-day, and to-morrow; still less one which implies any suspicion that, because of her constant parturition of specialisms geography is, or is likely to be in any future that can be foreseen, moribund.

Since geography, as I understand it, is a necessary factor in the study of all sciences, and must be applied to all if their students are to apprehend rightly the distribution of their own material, it is a necessary element in all education. Unless, on one hand, its proper study be supported by such means as the State, the universities, and the great scientific societies control, and, on the other, its application to the instruction of youth be encouraged by the same bodies, the general scientific standard in these islands will suffer; our system of education will lack an instrument of the highest utility for both the inculcation of indispensable knowledge and the training of adolescent intelligence; and a vicious circle will be set up, trained teachers being lacking in quantity and quality adequate to train pupils to a high enough standard to produce out of their number sufficient trained teachers to carry on the torch.

The present policy of the English Board of Education, as expressed in its practice, encourages a four-years' break in the geographical training of the young, the break occurring between the ages of fourteen and eighteen, the best years of adolescent receptivity. If students are to be strangers to specifically geographical instruction during all that period any geographical bent given to their minds before the age of fourteen is more than likely to have disappeared by the time they come to eighteen years. The habit of thinking geographically—that is, of considering group distribution—cannot have been formed; and the students, not having learned the real nature of the science applied, will not possess the groundwork necessary for the apprehension of the higher applications of geography. Moreover, as Sir Halford Mackinder has rightly argued, an inevitable consequence of this policy is that the chief prizes and awards offered at the end of school-time are not to be gained by proficiency in geography. Therefore, few students are likely to enter the university with direct encouragement to resume a subject dropped long before at the end of the primary period of their education.

It is not, of course, the business of schools, primary and secondary, to train specialists. Therefore one does not ask that pure geographical science should have more than a small share of the compulsory curriculum—only that it have some share. If this is assured, then its applications, which on account of their highly educative influence deserve an equally compulsory but larger place in the curriculum, can be used to full advantage. The meaning and value of the geographical ingredient in mixed studies will stand a good chance of being understood, and of exciting the lively interest of young students. In any case, only so will the universities be likely to receive year by year students sufficiently grounded to make good use of higher geographical courses, and well enough disposed to geography to pursue it as a higher study and become in their turn competent teachers.

The obligation upon the universities is the same in kind, but qualitatively greater. They have to provide not only the highest teaching, both in the pure science and its applications, but also such encouragements as will induce students of capacity to devote their period of residence to this subject. The first part of this obligatory provision has been recognised and met in varying degrees by nearly all British universities during the past quarter of a century. A valuable report compiled recently by that veteran champion, Sir John Keltie, shows that, in regard to geography, endowment of professorial chairs, allocations of stipends to readers, lecturers, and tutors, supply of apparatus for research and instruction and organisation of "honours" examinations, have made remarkable progress in our university world as a whole. But no British university has yet provided all that is requisite or desired. Oxford and Cambridge, which have well-equipped geographical laboratories, still lack professorial chairs. Liverpool, maintaining a well-staffed department of geography, and London, which, between University College and the School of Economics, provides all the staff and apparatus required for teaching, have endowed chairs; but they direct the attention of the holders to applications of geography rather than to the pure science. So also do the University of Manchester and the University College of Wales, both of which maintain professors of geography.

All the universities, with but one or two exceptions, examine in the subject to a high standard, that set by Cambridge being perhaps the highest over the whole field of properly geographical study. This latter university, also, has met the second part of her obligation to geography by the organisation of an honours course of instruction and classified examination, which, if pursued throughout a student's residence, is sufficient in itself to secure graduation. At Cambridge, therefore, geography may be said to stand on a par with any other self-contained final subject. Neither in London nor in Manchester (I am not quite sure about Liverpool, but believe its case to be the same) is geography, in and by itself, all-sufficient yet to secure graduation, though at London the supplementary subject is so far subordinated to geography that the degree is taken as in the latter subject. Oxford offers distinctly less encouragement at present than any of the universities just mentioned. Her teaching and her examination standard are as advanced as the best of theirs, and the highest award which she gives for proficiency in geography, her diploma "with distinction," counts towards the B.A. degree as two-thirds of the whole qualification; but—and here's the rub!—the balance has to be made up by proficiency in some other subject up to a pass, not an honours, standard. Therefore the resultant degree does not stand before the world as one taken in honours; and, although some candidates are notified as distinguished and some not in the geographical part of her examinations, the distinction is not advertised in the form to which the public is accustomed—namely, an honours list divided into classes. The net result is that an Oxford diploma, however brilliantly won, commands less recognition in the labour market than would a class in an honours school or tripos. It should, however, be mentioned—though an infrequent occurrence, not advertised by a class list, makes little impression on public opinion—that special geographical research, embodied in a thesis, can qualify at Oxford for higher degrees than the B.A.—viz. for the B.Litt. and B.Sc.—without the support of other subjects.

The reason of this equivocal status of geography at Oxford is simply that, so far as the actual faculties which control the courses for ordinary graduation are concerned, geography is, in fact, an equivocal subject. No one faculty feels that it can deal with the whole of it. The arts faculties will not accept responsibility for the elements of natural and mathematical science which enter into its study and teaching—for example, into the investigation of the causes of distribution, into the processes of surveying, into cartography, and into many other of its functions. Moreover, the traditional Oxford requirement of a literary basis for arts studies is hard, if not impossible, to satisfy in geography. The faculty of natural science, on the other hand, is equally loth to be responsible for a subject which admits so much of the arts element, especially into those applications of its data which enter most often into the instructional curriculum of adolescents—for example, its applications to history and to ethnology.

At this moment, then, there is an *impasse* at Oxford similar to that (it is caused by the same reason) which prevents the election of a geographer, as such, either to the Royal Society on the one hand, or to the British Academy on the other. But ways out can be found if there be good will towards geography, and such general recognition of the necessity of bringing it into closer relation with the established studies as was implied by the examiners in the Oxford school of Literae Humaniores last year, when, in an official notice, they expressed their sense of a lack of it in the historical work with which they had to deal. Faculties are comparatively modern organisations at Oxford as at Cambridge for the control of teaching and examining. Before them existed boards of studies, appropriated to narrower subjects; and, indeed, such boards have been constituted since faculties became the rule and side by side with them. The board, which at first controlled at Oxford the final honours school of English, is an example and a valid precedent. Cambridge has found it possible to organise a mixed board of studies to manage a final school of geography, the board being composed of representatives of both the arts subjects and the natural and mathematical sciences; and this acts apparently to the general satisfaction even in the absence of a professor of the special subject for the teaching and testing of which it was formed. Why, then, should Oxford not do likewise? If Cambridge has not waited for the endowment of a professorial chair in geography, need Oxford wait? I am well aware that, when at the latter university the school of English came into existence, there were already two chairs appropriated to its subject; and I grant that Oxford will not have the very best of all guarantees that a high standard will be maintained in the instructional courses and the examinations in geography until there is a professor *ad hoc*. But guarantees sufficient for all practical purposes she could obtain to-morrow by composing a board out of her existing teachers of geography and kindred sciences.

For the last time, then, let me rehearse the too familiar "vicious circle." The supply of good students depends on a supply of good teachers; the supply of good teachers depends on a supply of good students. If either supply fails, it is not geography alone, but all sciences and studies, that will be damnified; for all require the best of the help she can give in proportion as her science grows and improves. History will be able to call but indifferent geography to her assistance if this science has been understaffed and discouraged by official reluctance to allow it a place of its own in the sun. Is there not still some such reluctance on the part of the Board of Education, of some of our universities, and of the Civil Service Commissioners?

Stellar Parallax.

By J. JACKSON, Chief Assistant, Royal Observatory, Greenwich.

THE determination of stellar distances is fundamental to the investigation of the sidereal universe. When once the distance of a star is known, we can calculate its transverse speed in kilometres a second from its proper motion in seconds of arc per century, and we can determine its absolute brightness from its apparent brightness. For binary stars at known distances we can determine the separation of the components in kilometres, and this, together with the period, enables us to compute the mass of the system. Recent work at Mount Wilson has shown that it is practicable to determine the angular diameter of the larger stars, and for such stars a knowledge of the parallax will enable us to compute the linear diameter. Many of the investigations about the sidereal universe made during the last twenty years have been possible only through the increase in the number of stars the distances of which are known with reasonable accuracy, and the results obtained have been of such importance that in an increasing degree the energy of astronomers is being directed to supply the required data.

The direct determination of stellar distances depends on triangulation from the earth at different positions in its annual path round the sun. The apparent motion of a star can be analysed into a linear component due to the relative motion of the sun and the star, and a periodic motion due to the motion of the earth round the sun. The parallax of a star is the angle subtended by the earth's radius at the distance of the star, and is equal to the semi-major axis of the apparent ellipse described by the star as a result of the earth's orbital motion. It is therefore determined from observations made as nearly as practicable at the times when the star is at the ends of the major axis of the "parallactic ellipse."

The principle to be used in the determination of stellar distances was obvious as soon as the Copernican theory of the solar system was recognised. The difficulty in applying the principle is due to the extreme minuteness of the change in angle which is to be measured after a six months' interval. Had it been known or assumed that the stars were comparable in real brightness with our sun, although they appeared about a million million times fainter, it could have been calculated that their parallaxes were less than a second of arc. Successive attempts to measure the parallaxes of selected stars for long necessarily met with failure, although they led to many important discoveries. In the first half of the eighteenth century Bradley made a remarkable series of observations of the meridian zenith distance of the star γ Draconis—a star which passed the meridian near the zenith so that the angles to be measured were relatively small, while errors introduced by varying atmospheric conditions were reduced to a minimum. He discovered aberration and later nutation through these observations, and proved that the parallax of this star was less than a second. Observations of the same kind might later have led to the discovery of latitude variation. The attempt made by Sir William Herschel towards the end of the eighteenth century may also be noted here. Instead of attempting to determine the absolute parallax of separate stars which involves the measurement of large angles from the vertical or some other direction which it is supposed can be accurately identified after a six months' interval, he attempted only to discover relative parallaxes from the relative displacements of stars in nearly the same direction, but probably at very different distances. The method is essentially that now used almost exclusively; but where Herschel applied it to pairs of stars actually at different distances, his observations were not sufficiently accurate to reveal the parallactic motion. His most extensive series of observations were made of fairly bright pairs of stars within a few seconds of arc, and the motion he actually discovered was orbital motion of the stars, which proved that they were really close together in space and revolving round one another under gravitational attraction. This discovery led to the systematic study of double stars.

Success in the determination of stellar parallax was obtained almost simultaneously about 1838 by three observers employing different methods on different stars. The principal credit is usually given to Bessel for his determination of the parallax of 61 Cygni—a pair of faint stars with large proper motion—relative to faint neighbouring stars by means of the heliometer. This instrument consists of an ordinary telescope with the object glass cut in two along a diameter, and means are supplied for rotating the object glass and for sliding the two halves along their common diameter. With this instrument each star forms two images, and the observation consists in bringing an image of one star into coincidence with the other image of the other star. The heliometer can be used to measure angular distances of several minutes with an accuracy second only to that of the modern photographic telescope. The other determinations of parallax were by Struve, who observed α Lyræ relative to faint stars in its neighbourhood by means of a position micrometer as used for double stars, and by Henderson, who used meridian observations in both co-ordinates of α Centauri.

During the next fifty years a number of observers made parallax determinations by these three methods, but although they showed great skill in their work and prosecuted it with the greatest assiduity, it cannot be said that many trustworthy results were obtained. The errors to which even the best results are liable are shown by the following seven determinations of the parallax of Procyon made by Elkin with the Yale heliometer :—

0″·257 ± 0″·018	0″·503 ± 0″·049
0·461 ± 0·035	0·294 ± 0·019
0·367 ± 0·018	0·228 ± 0·020
0·366 ± 0·023	

Soon after the first application of photography to astronomy it was found that star places could be determined with great accuracy from photographic plates. It was only natural that attempts should be made to apply the new method to parallax determination. The initial results showed no greater accuracy than those obtained visually, but gradually the difficulties have been overcome, and a remarkable degree of accuracy attained. It might have been supposed that the development of a photographic plate would lead to a distortion sufficiently great to vitiate the results, but apparently this is not the case. In fact, the distortion is less than 0·001 millimetre and can be ignored. The difficulty is to eliminate systematic errors in the apparent centres of the star images on the plates so as to get the photographs to faithfully represent the heavens at the different epochs. Provision must be made for the automatic elimination of every imaginable source of systematic error, since every preconceived source of possible error has turned out to be a reality. The most important precautions to be taken were pointed out about twenty years ago by Kapteyn in the first of the Groningen Publications. These include the taking of all the photographs under as nearly as possible the same instrumental conditions—the telescope should always be on the same side of the pier, and as nearly as possible in the meridian. These precautions are now obvious, as not only is the objective liable to behave differently in different positions, but the atmospheric effect might vary differently for the different stars, as they are not all of the same colour. A more serious source of error, called the "guiding error," was pointed out by Kapteyn. For the brighter stars an impression is produced on the photographic plate more quickly than for the fainter stars, so that if during the exposure an error in guiding allows all the stars to be slightly displaced for a short time, the brighter stars will show an elongated image with a displaced centre, while the fainter stars will show round undisplaced images. For this reason Kapteyn urged the importance of good guiding. But it is impossible to guide sufficiently well, and the difficulty was satisfactorily surmounted only when Schlesinger introduced the occulting shutter. This is a sector which is made to rotate rapidly in front of the star the parallax of which is to be determined. By reducing the opening in the sector, the time during which the "parallax star" is exposed is reduced relatively to the other stars. It is usual for the comparison stars to be of the 10th or 11th magnitude, while the "parallax stars" are generally considerably brighter. It is possible by means of the rotating sector to cut down the brightness by five magnitudes. For the very bright stars this is not enough, and some observers have used two rotating sectors to give the required reduction. Another method is to place a screen in front of the brighter stars. It is now generally recognised that it is most important to have the parallax star and the comparison stars forming images of nearly equal size and density. At the same time, every care is made to have the guiding as accurate as possible. In this connection the exposure should be as short as will produce readily measurable images—two or three minutes with photographic refractors with an aperture of 20 or 30 in.

Kapteyn's plan was to photograph the region under consideration at three different epochs on the same plate, which was stored between the exposures and developed only after the third epoch. The times of exposure were chosen so as to give maximum parallactic displacement in one direction at the first and third epochs, and maximum parallactic displacement in the opposite direction at the middle epoch. For example, a region might be given three exposures in May of one year, six in the following September, and three in the next May. The telescope would be moved slightly between the exposures, and for each star there would be twelve images on the plate. As all the images of each star would lie close together, it would only be necessary to measure very small distances on the plate, while by a symmetrical arrangement of the images any possible distortion of the film would be eliminated. This method is ideal, and was applied to some extent, but on account of bad weather interfering with the exposures it has practically been abandoned. The photographs at the different epochs are now taken on separate plates, and this method allows of greatest weight being given to those exposures made under the best atmospheric conditions.

The difficulties to be overcome having been fully realised, and the necessary precautions having been devised, a large scheme for the determination of parallaxes has been undertaken. In this work the Allegheny, Dearborn, Greenwich, McCormick, Mount Wilson, Sproul, and Yerkes Observatories take part. The following table shows the aperture and focal length of the telescopes used :—

	Aperture. Inches	Focal length. Feet
Allegheny	30	46
Dearborn	$18\frac{1}{2}$	23
Greenwich	26	$22\frac{1}{2}$
McCormick	26	$32\frac{1}{2}$
Mount Wilson ...	60	80
Sproul	24	36
Yerkes	40	$62\frac{1}{2}$

The telescope used at Mount Wilson is a reflector, while the others are refractors. It will be seen that the focal length varies considerably from one instrument to another, but the probable error of a parallax determined from about fifteen plates is in all cases about 0·01″ or a little less. The explanation given is that with average conditions of working the images are larger for the longer telescopes. The aperture is also a point of some importance, as with larger aperture the duration of the exposure can be cut down, and with it the "guiding error." However, as some of the larger telescopes are really visual telescopes, and require a colour screen or special plates, the advantage they would otherwise have is reduced.

Considerable progress has already been made in carrying out this scheme of co-operation, and probably at least 200 parallaxes a year are being determined. The value of this contribution to our knowledge of stellar distances is realised when we recall that in 1880 we knew the parallaxes of only about twenty stars, while as late as 1915 the number had risen only to about 200. As one of the recent large publications we may instance the 260 determinations made at the McCormick Observatory in the five years 1914 to 1919.[1]

Let us consider the first star in this list. It is β Cassiopeiæ, a star of magnitude 2·4 with a proper motion of 55″ a century. The parallax was found from the rather large number of twenty-eight plates exposed as follows :—

1914	July	1	1916	Aug.–Sept. ...	4
	Nov.–Dec. ...	5		Nov.–Dec. ...	5
1915	Aug.	3	1917	Aug.	3
	Nov.–Dec. ...	3		Nov.–Dec. ...	4

The parallax found was 0·058″ ± 0·011″, in satisfactory agreement with other determinations, of which we may quote 0·051″ ± 0·015″ determined by Smith with the heliometer, and 0·074″ ± 0·011″ found by photography at the Allegheny Observatory. The proper motion in right ascension was found to be +0·524″, as compared with +0·529″ found by Boss from meridian observations extending through about 150 years. But the agreement is not always so satisfactory. Consider, for example, the star γ Ceti, which forms the double Σ 299. The components are of magnitudes 3·6 and 6·8, and are separated by about 3″. The duplicity of the star might well lie at the root of the trouble, although with suitable exposures the fainter star should not be seen. The parallax found with the Yale heliometer was 0·119″ ± 0·017″, that by photography at Allegheny 0·014″ ± 0·008″, and that at the McCormick Observatory 0·037″ ± 0·008″. The photographic parallaxes may be considered as in fair agreement, but the proper motion in right ascension was found to be −0·059″ (from plates extending $1\frac{1}{2}$ years), as against −0·147″ found by Boss from observations extending 150 years. The photographic proper motion was checked by plates giving an interval of $3\frac{1}{2}$ years, during which time the difference in proper motion amounted to no less than 0·3″. This cannot be explained by the orbital motion of the components, which is extremely slow, and it is difficult to attribute it to all four comparison stars, which on examination showed no appreciable proper motion. Results of this kind are by no means uncommon, and the greatest caution has to be used in applying small parallaxes from single determinations.

It may be considered that parallaxes greater than 0·05″ may be used in calculations concerning individual stars. For smaller parallaxes the accidental errors will make the results untrustworthy. It has been estimated[2] that there are about 2000 stars with a parallax as great as 0·05″, although most of them will be as faint as the 10th magnitude and not attract notice. As the number of stars to this magnitude is of the order of a million, it will be difficult to identify the stars which are near, but faint. Stars chosen at random will therefore generally give very small parallaxes. Most observing programmes, therefore, contain specially selected stars, such as very bright stars, stars with large proper motion, and binary stars in rapid orbital motion for which a fairly large parallax may be expected.

On account of this selection of the stars great care has to be exercised in discussions based on the measured parallaxes. Many facts, however, have been brought to light. The most important of these correlate what may be called the apparent qualities of a star with its absolute qualities. By the former we mean those qualities which can be found from observation without a knowledge of the distance, such as the nature of the light a star emits, or its angular motion, and by the latter the intrinsic qualities, such as real brightness, mass, and linear speed. Probably the most important results are those which have been reached at Mount Wilson, where for the later-type stars the relative intensity of certain spectral lines has been correlated with the absolute brightness. It is then a simple matter to deduce the distance from our knowledge of the absolute and apparent brightness. Parallaxes determined in this way are called "spectroscopic parallaxes," and recently a list of 1646 of these has been published by the Mount Wilson observers. Again, for double stars with known orbits and known parallax the mass of the system can be computed. It is found that the mass of all systems does not differ widely from twice that of the sun. Assuming this mass, we can compute "hypothetical" or "dynamical"

1 Publications of the Leander McCormick Observatory of the University of Virginia, vol. 3.

2 Eddington, "Stellar Movements," p. 15.

parallaxes from double stars for which the relative motion is known. Again, although the linear speed differs considerably from one star to another, the proper motions of stars can be considered as an index to the distance—a much better index than the apparent brightness.

In these and other indirect ways our knowledge of stellar distances is being rapidly advanced. It must be remembered that it is all ultimately based on measured or trigonometric parallaxes. The larger trigonometric parallaxes can be applied directly to the individual stars concerned, but for the smaller parallaxes the discussions must be of a statistical nature, as the errors of observation are too great. The indirect methods can, however, be pushed to stars at very great distances if only they appear bright enough for the necessary observations to be made.

Obituary.

JOHN ROBERT PANNELL.

JOHN ROBERT PANNELL, who was killed in the disaster to the airship R38 while making observations on behalf of the National Physical Laboratory, was the only surviving child of Mr. and Mrs. Pannell, of Nutley. He was born in 1885. A delicate childhood, which none would have suspected from his adult physique, interfered greatly with his education, but after courses at the Northampton Institute and some engineering works experience he joined the National Physical Laboratory in 1906 as a student assistant.

His best-known work is that carried out in conjunction with Mr. Stanton on dynamical similarity in the flow of liquids in pipes, which has become classical as the most complete demonstration of that principle in its important applications to hydrodynamics. With Mr. Stanton he also investigated with great elaboration the strength of welded joints; but most of his work is to be found in reports to the Advisory Committee for Aeronautics covering almost the whole range of experimental inquiry in aerodynamics. When problems of airship construction became prominent in 1916 he took part in most of the model measurements on resistance and the efficiency of controls; and when, again, after the war, it became possible to compare the results of model and full-scale tests, Pannell took charge of the latter and was constantly making observations on airships in flight.

In a science so little amenable to general theory the ability to make long and tedious series of routine measurements without allowing familiarity to breed carelessness is of special importance. This ability Pannell possessed in the highest degree. He had that genial serenity and evenness of temper often associated with one of his gigantic stature; neither the perversity of apparatus nor the impatience of petulant colleagues could make him relax for a moment the precautions that are the first necessity of such work. If the human tragedy of the R38 is partially compensated by a gain to science, that gain will be largely due to merits in Pannell's work which are too often eclipsed by more brilliant but not more useful achievements.

In private life the most lovable of men, he radiated kindness and good temper. He was of tireless physical energy, and his war-time leisure, devoted to a small farm, shamed the full-time occupation of many men. He leaves a widow, the true partner of all his labours, with whom all will feel sympathy in the exact measure of their acquaintance.

N. R. C.

WE learn, with regret, of the death on September 10, from drowning near Ottawa, of Mr. F. W. L. SLADEN, author of "The Humble-bee: Its Life-history and How to Domesticate It." Mr. Sladen was forty-five years of age.

THE death of Mr. JOHN PEARCE ROE took place on September 2. Mr. Roe was born in 1852, and was the chairman and managing director of Ropeways, Ltd., of London. He carried out a large amount of work in connection with the transporting of materials by means of aerial ropeways.

Notes.

THE *Chemical Age* announces that Sir William Pope has been elected an honorary fellow of the Canadian Institute of Chemistry.

IT is announced that the annual meeting for 1922 of the British Medical Association will be held at Glasgow on July 21–29. The authorities of Glasgow University have given the association permission to use the University buildings, and offers of assistance should be addressed to Dr. G. A. Allen and Dr. J. Russel at the University.

WE learn from the *Lancet* of September 17 that the Health Committee of the League of Nations is constituted as follows:—Dr. Léon Bernard, professor of hygiene in the University of Paris; Dr. G. S. Buchanan, senior medical officer of the British Ministry of Health; Prof. A. Calmette, director of the Pasteur Institute in Paris; Dr. Carozzi, medical director of the International Labour Bureau; Dr. Henri Carrière, director-general of the Swiss Public Health Service; Sir Havelock Charles, president of the Medical Board for India; Dr. Chodzko, Minister of Health for Poland; Dr. Lutrario, director-general of the Italian Public Health Service; Dr. Th. Madsen, director of the State Institute of Serotherapy at Copenhagen; Prof. Miyajima, of the Kitasato Institute for Infectious Diseases, Tokyo; Dr. Pulido, president of the Spanish Royal Council of Public Health;

Mr. O. Velghe, director-general of the Belgian Public Health Service; and Prof. C.-E. A. Winslow, director of the League of Red Cross Societies. Dr. Rajchman, of Warsaw, has been appointed permanent medical director.

THE following lectures have been arranged for delivery at the Royal College of Physicians:—The Mitchell lecture, on "The Relations of Tuberculosis to General Conditions of the Body and Diseases other than Tuberculosis," by Dr. F. Parkes Weber, on November 1; The Bradshaw lecture, on "Sub-tropical Esculents," by Dr. M. Grabham, on November 3; and the Fitz-Patrick lecture, on "Hippocrates in Relation to the Philosophy of his Time," by Dr. R. O. Moon, on November 8 and 10. The time in each case will be 5 o'clock.

THE autumn meeting of the Refractory Materials Section of the Ceramic Society is to be held at the Institution of Mechanical Engineers on Thursday and Friday, October 6 and 7, when the following papers will be read:—"Refractory Materials of the London Basin," H. Dewey; "The Marlow Gas-fired Tunnel Oven," J. H. Marlow; "A New Type of Tunnel Kiln, Oil-fired, with many Novel Features," P. J. Woolf; "Aluminothermic Corundum as Refractory Materials," Dr. A. Granger; and "The Reversible Thermal Expansion of Silica," Prof. J. W. Cobb and H. S. Houldsworth. There will also be a discussion on gas-firing.

THE secretary of the Royal Geographical Society has received a cablegram from Mr. J. M. Wordie, of St. John's College, Cambridge, announcing that the expedition of Mr. Wordie and Mr. Chaworth-Musters, of Caius College, to the Island of Jan Mayen this summer has been very successful, and that the first ascent of Beerenberg, the very summit of the island, has been made.

ACCORDING to the *Morning Post*, an expedition to Sumatra, under the leadership of Mr. C. Lockhart Cottle, is to sail towards the end of the year for the purpose of making zoological and museum collections. A special effort will be made to obtain particulars of the life-history of the orang.

A JOINT research committee has been formed by the National Benzole Association and the University of Leeds which will take over the direction of research in the extraction and utilisation of benzole and similar products in this country. The National Benzole Association is concerned with the production of crude and refined benzole, and, according to its constitution, one of its objects is to carry on, assist, and promote investigation and research. The term "benzole" is used in its widest sense, so the field of activity of the association embraces carbonisation and gasification processes, by-product coke-oven plants, gasworks, etc., but at the present time it is concerned mostly with the promotion of home production of light oil and motor spirit. Success in this direction is thought to rest largely with chemical investigations into the possibilities of the various processes concerned, and it is with this object that co-operation with the University is sought. The joint committee which has been formed consists of equal numbers of representatives from the University and the association, and the initial membership is as follows:—Prof. J. W. Cobb, Prof. J. B. Cohen, Prof. A. G. Perkin, Prof. Granville Poole, Prof. A. Smithells, Mr. W. G. Adam, Dr. T. Howard Butler, Mr. S. Henshaw, Mr. S. A. Sadler, and Dr. E. W. Smith. Research work undertaken will be carried out under the supervision of Prof. Cobb, and reports embodying the results will be published at intervals.

THE annual exhibition of the Royal Photographic Society was opened on Monday last at 35 Russell Square, W.C.1, and will remain open until October 29. Admission is free. The greatest novelty from a scientific point of view is a portrait of the Postmaster-General by M. Louis Lumière's new method of showing the solidity of solid objects by means entirely different from the ordinary stereoscopic method. Separate photographs are taken of, say, six different planes of the object, and the camera is so constructed that while the relative positions of the object, the lens, and the plate remain fixed so far as regards the plane being photographed, a movement of the plate and the lens renders unsharp the images in the other planes. Thin transparencies are then made from the negatives, and these are placed in properly spaced grooves one behind the other. A diffused light is arranged behind, and the whole is viewed, normally, from a distance of a yard or so. The result shown is strikingly good so far as the face is concerned, the definition being a little soft. The edge of the collar, where there is great contrast, shows a double or multiple image. Mr. Howard M. Edmunds illustrates a method of photo-sculpture. An image of an accurately drawn spiral line is projected by means of a lantern on to the face of the subject while a photograph is taken of him. A high-speed drill does the carving, and it is guided by "sighting a microscope attached to it on to" the special portrait described. A large series of photographs of spiders, butterflies, moths, etc., taken by flashlight without regard to the time of day or night except as the character of the subject renders necessary, is shown by Mr. Oswald James Wilkinson. The results are excellent, most of the pictures being life-size. There are many radiographs of great interest, astronomical photographs from Greenwich, two photographs of a waterspout by Mr. J. W. Knight, and innumerable other examples of good scientific work, besides the pictorial section. The society's museum, which has lately been enriched by a large quantity of apparatus used by Fox Talbot, is well worth a visit on its own account.

DURING the meeting of the British Association at Edinburgh Prof. W. D. Halliburton delivered a lecture on giants. He said that the popular conception of a giant was that he was a powerful, magnificent man, and very often used that power to the detriment of the races of mankind. As a matter of fact, a giant was a feeble and usually short-lived person, and destitute of the features associated with masculinity. It was now established that certain organs, such as the thyroid gland and the pituitary body at the base of the brain, had vast potentialities and great value. Giganticism was due to the over-activity of the pituitary body from birth, or sometimes before it; but it occasionally happened that this over-activity came into play after the increase of height was no longer possible, and this was evidenced in an overgrowth of the extremities, which was technically called acro-megaly. It was very striking that portions of a man's brain could be removed, as was done in the recent war, but this tiny thyroid gland was of prime importance; its entire removal was followed by death within a very short time, and its over-activity or under-activity determined whether men were big or small.

AT the Edinburgh meeting of the British Association Sir W. Ridgeway extended to totemism the theory of ancestral worship which he has applied, in his "Origin of Tragedy," to the investigation of the drama. A prominent part in its development has been played by transmigration, as in the case of the ancient Egyptians. Some Indonesians venerate the crocodile as a beneficent being, and look forward to becoming crocodiles after death, while tribes in Sumatra venerate tigers, supposing them to be their ancestors. Thus the reverence for certain trees, animals, etc., depends on the primary belief in the immortality of the soul. There can be no doubt, as some authorities stated in the course of the discussion which followed the reading of Sir W. Ridgeway's paper, that totemism is often found in connection with the cult of ancestors. But the difficulty remains that transmigration or the immortality of the soul does not seem to be one of the earliest and fundamental beliefs that arose in the human mind, and that totemism displays itself in many parts of the world as a complex form of belief, the varieties of which cannot easily be explained by any single theory of its origin.

IN the September issue of *Man* Messrs. Buxton and Hort give an interesting account of the pottery industry of Malta, the facts having been collected during the visit of the Oxford Anthropological Expedition. Two methods, the old and the new, are in use. In the former method we have a baked clay support holding a wooden disc set spinning by the hand in a clockwise direction—a method occasionally used for making ollas, or large water-pots, but now falling into disuse. In the new method an iron spindle, with the point in the native rock-floor, is used, the lower disc being turned anti-clockwise with the foot, and the clay worked on the upper turn-table. This method has been in use only for about ten years, and one woman did not know how to work the modern wheel.

IN the current issue (vol. 22, part 2) of the Records of the Indian Museum two entomological discoveries of unusual importance are put on record. The first is that of a dragon-fly of the genus Epiophlebia in the Himalayas. This genus, which appears to combine the characters of the Zygoptera and the Asisoptera, is an exceedingly archaic form, and has hitherto been known from a single Japanese species. A larva sufficiently advanced in development to be identified with certainty was found in a small collection from the Darjeeling district by Dr. F. F. Laidlaw, who, recognising its importance, has persuaded Dr. R. J. Tillyard to describe it in detail. The larva of this remarkable genus was hitherto unknown, and the extension of the geographical range from Japan to the Himalayas is a matter of great interest. The second discovery is that of a species of the termitophilous hemipterous genus Termitaphis on the east coast of India. The genus consists of curious flattened, wingless insects superficially resembling Coccidæ or Aphidæ, but conforming in structure to the Heteroptera. Species have hitherto been found in the warmer parts of North America, in South America, Australia, and West Africa, but not in the Oriental region. Prof. F. Silvestri, who describes the Indian form from a nest of *Coptotermes Heimi*, regards the genus as representing a distinct family, which he calls Termitocoridæ.

WE have received the General Report of the Survey of India for the year 1919–20. Field-work still suffered from a shortage of officers, but this difficulty was being overcome. Topographical surveys during the year covered 30,464 square miles, including large areas in Upper Burma and Tenasserim. Among the new sheets published were 104 1-in. sheets, 39 ½-in. sheets, and 8 "degree" sheets. Two new sheets of the million map were produced, and practically the whole of India, Afghanistan, Persia, and parts of Burma are now published on this scale. No additions were made to the two-million series. The report includes indices to the maps of various scales.

THREE papers in the Records of the Geological Survey of India (vol. 53, part 1, 1921) bear on the development of minerals of economic interest, but are in no case of a very hopeful nature. Dr. A. M. Heron describes lodes of antimonite 20 ft. wide south of Moulmein, Burma, in a district where labourers may be described as evanescent. Mr. H. C. Jones notes numerous occurrences of the same ore in the southern Shan States, none being of marked importance. Mr. G. H. Tipper gives a summary, from a recent journey, of "The Geology and Mineral Resources of Eastern Persia." Here the continuous destruction of forests has left no fuel for smelting ore. An interesting account is given of the long underground tunnels, often lined with glazed pipes, which convey water from the gravels for irrigating land lower down the slopes.

AN important study of the origin of banded gneisses and amphibolites occurs in Mr. C. E. Tilley's paper on "The Granite-gneisses of Southern Eyre Peninsula, S. Australia" (Quart. Journ. Geol. Soc. London, vol. 77, p. 75, 1921). The production of the characteristic granular garnets and secondary pyroxenes of amphibolites from primary pyroxene, in a basic igneous rock invaded by granite, is excellently described. We may note again that in discussions of the banding of composite gneiss justice is rarely done to the work of Lévy, Lacroix, and Callaway (in Co. Galway), which dates back at least to 1887.

A MEMORANDUM has been issued under the direction of the Indian Government by Dr. Gilbert T. Walker, Director-General of Indian Observatories, on the rainfall of June and July and the probable amount during August and September, 1921. The monsoon appeared over the various parts of the country at about the normal times. The combined rainfall of June and July over the plains of India as a whole is said to have been nearly normal, the deficiency being only 1 in., or 5 per cent., but there was a deficiency of more than 20 per cent. in the United Provinces West, the Punjab east and north, the North-West Frontier Province, Baluchistan, Central India East, and Malabar. The memorandum gives the actual rainfall for the separate months June and July and the departure from the normal for the fifteen chief political divisions and the thirty-three sub-divisions of India. Details are given of the recent data regarding the conditions most likely to have influence on the rains of August and September, 1921; atmospheric pressure over India and the snowfall in mountain regions, as well as the meteorological conditions over the Indian Ocean and in other parts are discussed. From these conditions it is summarised that in North-West India, including the west of the United Provinces, and in the Peninsula, it is likely that the total rainfall of August and September will exceed the average. For North-East India and Burma the conditions are said to be too uncertain to justify a forecast.

ABOUT five years ago Prof. Omori made some interesting seismometric measurements of the movements of the great chimney at Saganoseki under the action of wind (NATURE, vol. 101, 1918, p. 436). It was found that the top of this chimney, 550 ft. in height, moved through a total range of 7¾ in. when the velocity of the wind was 78 miles an hour. The most interesting result of the measurements was that this movement took place at right angles to the direction of the wind. With the wind the range was always under 1 in. Prof. Omori has recently repeated these experiments on other columns (Bull. Imp. Earthq. Inv. Com., vol. 9, 1921, pp. 77–152). The most lofty is the reinforced concrete tower of the new wireless telegraph station of Haranomachi. This is a hollow, truncated cone, 660 ft. in height, with an external diameter of 57 ft. 9 in. at the base, and of 4 ft. 6 in. at the top, the thickness of the concrete wall being 33 in. and 6 in. respectively. The tower is situated about 200 km. from the principal earthquake zone off the east coast of Japan. The movements were registered by a portable two-component tremor-recorder magnifying from 10 to 30 times. Experiments were made at various times during the construction and after the completion of the tower, the maximum velocity of the wind varying from 20 to 45 miles an hour. It was found that the movements were quite insignificant until the height of the column was 290 ft., and they became distinct only when the height exceeded 500 ft. On completion, the maximum range (or double amplitude) was 6·9 mm., but this was increased to above 10·3 mm. when the iron frame, weighing more than two tons, was attached just below the top. The range of 6·9 mm. was attained in the direction perpendicular to that of the wind. With the wind the maximum range was only 1·9 mm. The period of vibration of the completed column was 2·07 seconds, or 2·12 seconds after the addition of the iron frame. Prof. Omori has also measured the vibrations of a twelve-story brick tower, 172 ft. high, at Tokyo, and of six five-story Buddhist pagodas in various parts of the country.

AT the Washington meeting of the American Physical Society in April last Prof. W. F. G. Swann, of the University of Minnesota, directed attention to the influence of the size of the earth on certain changes in terrestrial magnetism. The method of investigation is not exact from the mathematical point of view, but keeps the physical principles involved in the calculation clearly to the fore. In the first place, it is shown that electric currents once started in a copper sphere of the size of the earth would decrease to 37 per cent. of their initial value in 3,000,000 years. In the second, that if such a sphere were originally magnetised and means were then taken to demagnetise it, the same statement would hold for the magnetism. In the third place, if the so-called secular variation of the magnetisation be regarded as due to the rotation about the earth's axis once in 500 years of a uniform magnetisation perpendicular to that axis, the interior conductivity of the earth must be of the order 1/30,000 of that of copper. In the short paper in the issue of the Journal of the Washington Academy of Sciences for June 19, which is the only account of Prof. Swann's conclusions at present available, he points out that corresponding statements may be made with respect to the sun.

WITH reference to the inquiries made by Mr. Hedger Wallace in a letter entitled "Cornalith" published in NATURE of August 25, p. 811, we learn from Messrs. Erinoid, Ltd., of Lightpill Mills, Stroud, Gloucester, that cornalith and galalith are both trade names used by different firms for ivory and horn substitutes, etc. Galalith is the trade name for a casein-formaldehyde material manufactured by the Galalith Co. of Germany; cornalith is presumably the name selected by one particular firm to indicate that imitations of horn are their chief products. In England casein-formaldehyde products are manufactured and sold as raw material under the name of "erinoid," and Messrs. Erinoid, Ltd., claim that their output, nearly 700 tons, during the past year is far in excess of the combined output of both galalith and cornalith factories. The firm exhibited some of their products at the British Scientific Products Exhibitions organised in 1918 under the auspices of the British Science Guild. Vegetable casein has not so far proved as suitable as milk casein for the manufacture of casein-formaldehyde material, but if the Galalith Co. chose to send out an inferior product made from vegetable casein, there is nothing to prevent them from applying to it their own trade-name "galalith."

MESSRS. CHARLES BAKER, of 244 High Holborn, W.C.1, have issued recently a new classified list (No. 73) of second-hand scientific instruments and books. The catalogue contains a number of microscopes, of wide range in size and price, and many object-glasses, eye-pieces, and other accessories are also listed. Surveying instruments, particularly theodolites and levels, are well represented. In the section devoted to telescopes, a number of second-hand instruments, both reflectors and refractors, on equatorial and altazimuth mounts, are offered for sale. The list includes a 12-in. reflector and a 12-in. and a $7\frac{1}{4}$-in. refractor, as well as several smaller instruments, object-glasses, eyepieces, sidereal clocks, and other astronomical apparatus. A series of lantern-slides has been prepared to show the appearance of the bright line spectra between the limits 4000–7000 Å.U. of the commoner elements with normal dispersion. Slides of twenty-seven elements are now available; they should be of considerable service to science teachers. Other features of the catalogue are the sections dealing with cameras and other photographic apparatus and books; the latter contains, among a number of useful text-books and series of scientific periodicals, vols. 28 to 104 of NATURE.

THE Cambridge University Press is publishing the three following books in the autumn :—"New Mathematical Problems," by Major P. A. MacMahon; "Series Spectra," by Dr. Norman R. Campbell; and "Weather Prediction by Numerical Process," by L. F. Richardson. The first-named will be problems based on the permutations and combinations of elementary geometrical shapes; the second will be the first of the supplementary chapters to the author's "Modern Electrical Theory," to which allusion has already been made in NATURE (February 24, p. 842); and the third embodies a scheme of weather prediction, resembling the process employed in the production of the *Nautical Almanack*. At the close of the present year the same publishers will issue "Alternating Currents," in two parts, by C. G. Lamb. It is intended as a guide to the student attending a three-term course on the subject.

Our Astronomical Column.

SEPTEMBER METEORS.—Mr. W. F. Denning writes :—"An excellent series of abundant observations were obtained during the first ten days of the present month by Miss A. Grace Cook and Mr. J. P. M. Prentice at Stowmarket, and several hundred meteor paths were carefully recorded, from which a number of interesting radiant points were derived. These include various systems which have been well observed in past years, and several which apparently represent new showers.

"An active radiant of Orionids from $91\frac{1}{2}°+8\frac{1}{2}°$ was detected on September 1–3, which seems to have escaped previous observation; and among the old streams we observed were the ϵ Arietids, α Cassiopeids, α–β Perseids, and ι Aurigids.

"Fireballs are usually very frequent in September, and the present month has proved no exception. Several brilliant meteors from Capricornus were observed on September 6, 7, and 14. On September 7 and 8 large meteors were seen from a radiant in Auriga, and on September 10 two brilliant objects were recorded, possibly from a radiant near α Cygni. The times of the two latter were at 9.10 and 11.40 G.M.T., and further observations of these various objects would be valuable. This display of Cygnids is a long-continued one, and was noted as specially active on September 12, 1918, as seen from Bristol."

IONISATION IN STELLAR ATMOSPHERES.—Dr. M. N. Saha has published an important series of papers on this subject in *Phil. Mag.* (vols. 40 and 41) and in Proc. Roy. Soc., 99 A (1921). A useful summary and *critique* of these is given by Mr. E. A. Milne in *Observatory* for September. The work consists of two parts: the study of the conditions of ionisation by the formulæ of physical chemistry, and an endeavour to explain some of the features of solar and stellar spectra in the light of the results. Taking calcium as an example, the percentage of ionisation at different temperatures and pressures is tabulated; the table indicates that at the surface of the sun both normal and ionised atoms of calcium should be plentiful, and, in fact, the *g*, H, K lines are all present. On the other hand, at great heights above the photosphere the pressure is small and ionisation almost complete; accordingly, only the enhanced lines H, K are visible here, *g* not being traced beyond a height of 5000 km. Analogous results are given for several other elements, and hope is held out that the method may eventually afford an indication of the pressure at various heights above the photosphere.

Lessons are also deduced from the progressive appearance and disappearance of certain lines as we pass along the series of stellar spectra from M to O. Dr. Saha determines the temperature of each type, his values ranging from 23,000° Oa, 18,000° Bo, to 5000° Ma, and 4000° Md. These are in fair accord with those of Russell, Wilsing, and Scheiner, but slightly higher on the average.

It will be remembered that several astronomers have suggested that, the supply of gravitational energy being insufficient to maintain their output, the stars are drawing on the energy of the atom. It is likely, therefore, that atomic chemistry will play an important part in the astronomy of the future.

VARIABLE STARS.—Observations of seventy-two well-known variable stars, the R.A.'s of which range from 5h. 21m. to 24h., were made by Prof. Vojtěch Šafařík at Prague between the years 1877 and 1894. They are reproduced in great detail by Prof. Ladislav Pračka in a publication recently received ("Untersuchungen über den Lichtwechsel Älterer Veränderlicher Sterne. Nach den Beobachtungen von Prof. Dr. Vojtěch Šafařík." Vol. 2, pp. iii+180. Prag: Fr. Řivnáč, 1916). The magnitudes of the comparison stars are discussed and compared with all available authorities; the differences of magnitude between them and the variables are given in full, and the nature of the light curve, with the dates of maximum and minimum, is discussed in all cases where the observations suffice for the purpose. There are also many estimates of colour, on Schmidt's numerical scale, which represents white by 0, yellow by 4, orange by 7, red by 9 to 10. The long-period variables in this volume are without exception orange or red; eleven of them have colour-estimates extending beyond 9, and one star, S Cephei, has a colour-estimate of 10.

The following stars have especially long and full series of observations: R Leonis, R Camelopardi, R Draconis, R Aquilæ, U Cygni, V Cygni, S Cephei. Observations of two novæ are included in the volume. Nova Aurigæ fell from 5m. to 11m. in a few weeks early in 1892, then revived to 9·2m. early in 1893, being 9·9m. at the end of that year. Nova T Coronæ appeared to remain steady at 9·2m. during the years 1886 to 1894.

Spontaneous Combustion in Coal Mines.

THE final report of the Departmental Committee appointed by Mr. McKenna in 1912 "to inquire into the circumstances in which spontaneous combustion of coal occurs in mines, its causes and the means of preventing it or of dealing with it," has now been issued.[1]

In form it is a model of what such a report should be; it opens with an historical review of the subject from the seventeenth century, it proceeds to summarise and analyse the scientific evidence collected during the last ten years, and then considers the conditions which are found in practice to be conducive to spontaneous ignition in coal-mines and the means of preventing or extinguishing such fires.

The question whether coal can ignite *per se*, or whether this is effected through the heating of an impurity, *e.g.* iron pyrites, has long been in dispute, the older opinion, both among practical men and chemists, inclining strongly to the view that the oxidation of pyrites is the primary cause of the ignition.

In an interesting quotation from Dr. Plott's "Natural History of Staffordshire" (1686) we learn that the shale and small coal left in the hollows of old workings will fire "natural of themselves," and "have done beyond all memory." The seat of the heating is said to be a mixture of the "laming," that lies between the measures of the coal, and the "sleck" when "very much mixed with brass lumps." Plott evidently leans to the pyrites theory, and quotes Dud Dudley and Dr. Powers as vouching for the statement that small coal and sulphurous sleck when moistened and exposed to the air will turn red-hot of themselves. The experience of mining engineers, who found as a fact that fires mainly occurred in seams rich in pyrites (as in South Staffordshire) and were absent in coalfields (such as the Durham field) where the pyrites is very low—backed as this experience was by the authority of chemists from Berzelius to Liebig—led to the almost universal belief in pyrites being the sole cause of ignition. Dr. Percy in 1864 seems to have been the first to suggest that coal could itself absorb oxygen and become heated, and this view received much support from the experiments of Dr. Richters, of Waldenburg, who showed that fine coal with very little pyrites in it would absorb oxygen and heat up, while the pyrites itself showed very small absorption. The Royal Commission appointed in 1876 to inquire into the spontaneous combustion of coal in ships regarded pyrites as the primary cause, but found that the condensation of oxygen on the surface and the subsequent oxidation of the coal matter were "contributory" causes.

Since that date experiments in France, mainly those of Henri Fayol, and in Germany on the seams of Upper Silesia (where fires are frequent), have shown that the condensation and absorption of oxygen from moist air by coal itself—especially when the coal is in a thick layer—are the important factors in spontaneous combustion, while the oxidation of pyrites (marcasite) is a less important factor. Up to the end of the last century we may say that the pyrites theory had the larger following; but since the report of the German Commission in 1910 scientific opinion has changed, and the opinion of practical men has been doubtful.

The verdict of the Committee—a body of men practically familiar with coal-mining—that they are satisfied on the scientific evidence brought before them that coal subject to spontaneous firing owes this property, not to its pyrites content, but to the direct oxidation of the coal matter, should set at rest all reasonable doubt and concentrate attention on the real cause. That some heat may be generated by the oxidation of marcasite is admitted, but its direct effect is negligible. Where pyrites may play a part is in the disintegration of coal whereby the latter may become more permeable by air, and so more readily oxidised.

In arriving at their conclusions the Committee was largely influenced by the experimental work of Prof. Bedson, Sir R. Threlfall, Dr. Wheeler, and Dr. Haldane, who were in close agreement; and where there still appeared to be some doubt, *e.g.* in the case of the Bullhurst seam (North Staffordshire) and in that of the Barnsley seam (Yorkshire), the Committee requested Dr. Wheeler to carry out special experiments for them. These experiments are quoted in full and appear conclusive. The Committee directs attention to Dr. Wheeler's statement that the higher the oxygen content of a coal the lower is its temperature of self-ignition, and emphasise the practical importance of the fact that a coal containing more than 10 per cent. of oxygen is liable to inflammation—or, at all events, is suspect—whereas a coal containing less than 6 per cent. may be regarded as non-suspect.

It is interesting to note that the work of the palæobotanists is not neglected, and that the "fusain" of Dr. Marie Stopes—the mother-of-coal—(shown by her to be woody fibre) forms at its juncture with "vitrain"—glance coal—the critical point of any piece of coal with regard to inflammation—a conclusion which recalls Dr. Plott's statements as to the mixture of "laming" with "sleck."

The remaining sections of the report deal with the practical aspects of the subject, and give many technical suggestions for preventing and dealing with gob-fires. One of the most important points discussed is the practicability of hydraulic stowage—a certain cure if it could be worked.

[1] Departmental Committee on Spontaneous Combustion of Coal in Mines. Final Report of the Departmental Committee on Spontaneous Combustion of Coal in Mines. (Cmd. 1417). (London: H.M. Stationery Office.) 1s. 6d.

Lighting of Factories and Workshops.

IN 1913 a Departmental Committee was appointed by the Home Secretary to inquire into the lighting of factories and workshops. The Committee issued in 1915 an interim report containing much valuable information which attracted much attention and still holds a unique position amongst official literature on this subject. On that occasion statutory provisions requiring adequate and suitable lighting in every part of a factory and workshop were recommended. Values of illumination were also prescribed in the interests of safety and convenience, but detailed recommendations on the order of illumination necessary for various industrial processes were deferred.

The work of the Committee, suspended during the later stages of the war, was resumed in 1920, and a second report defining with greater precision the phrase "suitable lighting" has recently been issued (Cmd. 1418, 1d. net). The report deals specially with the three factors of glare, shadow, and constancy.

Glare may arise through the presence of unduly bright lights in the direct field of vision or on the edge thereof, or through inconvenient direct reflection of light from shiny or polished material. Four requirements bearing on the above points are now suggested :—

(1) Every light source (except one of low brightness[1]) within a distance of 100 ft. from any person employed shall be so shaded from such person that no part of the filament, mantle, or flame is distinguishable through the shade, unless it be so placed that the angle between the line from the eye to an unshaded part of a source and a horizontal plane is not less than 20°, or in the case of any person employed at a distance of 6 ft. or less from the source not less than 30°.

(2) . . . "Adequate means shall be taken, either by suitable placing or screening of the light sources, or by some other effective method, to prevent direct reflection of the light from a smooth or polished surface into the eyes of the worker."

(3) . . . "Adequate means shall be taken to prevent the formation of shadows which interfere with the safety or efficiency of any person employed."

(4) . . . "No light sources which flicker or undergo abrupt changes in candle-power in such manner as to interfere with the safety or efficiency of any person employed shall be used for the illumination of a factory or workshop."

In view of the fact that extensive alterations may be occasioned by compliance with these requirements, it is further prescribed :—

(5) "That, as regards existing installations, a reasonable time limit should be given before the above requirements become operative."

An appendix to the report contains extracts from codes adopted in various American States and recommendations made by the Illuminating Engineering Society in Germany.

[1] *I.e.* with an intrinsic brilliance not exceeding 5 candles per sq. in.

The World's Wheat Supply.

THE statistics dealing with the wheat supply of the world are discussed by Sir James Wilson in an interesting and exhaustive paper entitled "The World's Wheat," contributed to the Journal of the Royal Statistical Society (vol. 84, part 3, May, 1921).

Having pointed out the varying accuracy of available statistics and explained the system of calculation adopted, the author gives the pre-war five-year average yields for all wheat countries, together with the exports and imports. For this period the world's yield was 107 million metric tons, of which 22·2 million metric tons—more than one-fifth of the whole—were produced by Russia. The net world exports amounted to 18·5 million metric tons, of which Russia again contributed the largest proportion, nearly one-fourth of the whole; while of the net imports of 18·0 million metric tons Great Britain was the largest importer with 5·9 million metric tons, followed by Germany with 1·9 million metric tons. Naturally, these figures were all profoundly affected by war conditions. Statistics are not available for such important countries as Germany, Austria, and Belgium among the importers, nor for Russia, Rumania, Hungary, and Bulgaria among the exporters, but for the twenty-one countries where figures have been published the average yield was 66·8 million metric tons during the war, compared with 63·1 million metric tons before the war. The importing countries on the average produced less than before the war, but they also imported less. Britain increased her average yield from 1·6 to 1·9 million metric tons and reduced her average net import from 5·9 to 5·2 million metric tons and her average consumption from 7·5 to 7·1 million metric tons. The exporting countries—United States, Canada, and Argentina—all increased their yields considerably, and also their exports. Australia increased her yield, but her average export was much the same as the pre-war average, probably on account of the large loss of stored wheat by mice and weevil depredations. India's average yield during the war was practically the same as the pre-war average, but owing to the export restrictions enforced by the Government in the interests of the consumers her average net export fell from 13·5 million metric tons before the war to 8·2 million metric tons during the war period.

With regard to the supplies of 1919 and 1920, excluding Russia and Rumania (which in the pre-war average exported nearly one-third of the world's net exports) and India (export from which country was practically prohibited), the other exporting countries began the cereal year on August 1, 1919, with about 6·1 million metric tons of exportable supplies still in hand, while there was also a large quantity on its way to the importing countries. All the importing countries together in 1919–20 imported 18·2 million metric tons, which is about the pre-war average, and during that year the Argentine and Australia got rid of their embarrassing surplus, while towards the end of the year the United States had practically a monopoly of export, and so obtained very high prices. Sir James Wilson estimates that for the current year ending July 31, 1921, there will be 18·9 million metric tons available to meet the estimated demand of 17·0 million metric tons, which will leave a sufficient, though not excessive, margin on the eve of the ripening of the new harvests in the northern hemisphere.

It is to the temporary advantage of consumers that there should be an excess of supply over demand, and to the temporary advantage of producers that the demand should exceed the supply; but for the world as a whole it is better that supply and demand should approximate. In the author's opinion, from the information available at the time, this condition should be reached as regards wheat on August 1, 1921, and according to present prospects (excluding Russia, Rumania, and India) the harvest to be reaped after that date will yield sufficient to meet the world's probable demands. For the more distant future fears are sometimes expressed that the growth of the world's population, and especially of the number of wheat-eaters, will result in a permanent dearth of wheat, but it must be remembered that the great majority of mankind prefer grains other than wheat, and even the wheat-eaters substitute other grains without much sense of hardship.

With regard to wheat prices, in most European countries at the present day the high prices of wheat are largely due to the depreciation of the various paper currencies. The author discusses the different factors which will affect the wheat prices—rates of exchange, freight charges, etc.—and concludes that, so far as Britain is concerned, the price of wheat will be lowered if "the rate of exchange with the United States of America improves, and if Asia and South America continue to absorb gold at a great rate, and so help to reduce the prices of all commodities, measured in gold, all the world over."

University and Educational Intelligence.

LONDON.—The following special advanced lectures have been arranged at King's College for post-graduate and other advanced students. The dates given are those on which the courses begin :—"Liquid Fuels," Mr. Harold Moore, October 17; "Liquid Fuel Engines," Dr. W. R. Ormandy, October 24; "Bridge Construction," Mr. H. W. FitzSimons, October 13; "Cascade Induction and Synchronous Motors and Generators," Mr. L. J. Hunt, October 18; "Reinforced Concrete," Dr. Oscar Faber, January 19, 1922; "Accurate Measurements in Mechanical Engineering: The Use and Testing of Gauges," Mr. F. H. Rolt, January 24; "Wireless Transmitting Valves," Prof. C. L. Fortescue, January 23; and "The Cheapening of Electrical Energy in Great Britain," Mr. C. H. Wordingham, February 27.

OXFORD.—Mr. J. H. Jeans, secretary to the Royal Society, has been appointed Halley lecturer for 1922.

BIRMINGHAM.—By the retirement of Mr. W. H. Cope, the University librarian, the University loses a valuable servant whose place will be difficult to fill. In forty years of strenuous and whole-hearted devotion to duty Mr. Cope has brought the rapidly growing library to a state of efficiency out of all proportion to the expenditure involved. Regardless of the fact that his salary was a mere pittance and that the library was deplorably understaffed, he always gave of his best; and by his ever-ready assistance he earned the gratitude of many generations of staff and students, whose good wishes will follow him into his retirement.

THE Herter lectures are to be delivered at Johns Hopkins University, Baltimore, on October 5, 6, and 7 by Sir Arthur Keith, who will take as his subject "The Differentiation of Human Races in the Light of the Theory of Hormones."

DR. D. BURNS, Grieve lecturer on physiological chemistry in the University of Glasgow, has been appointed professor of physiology in the University of Durham College of Medicine, Newcastle-upon-Tyne, in succession to the late Prof. J. A. Menzies.

AMONG the free public Gresham lectures shortly to be delivered at Gresham College are the following :—Physic, Sir Robert Armstrong-Jones, October 11, 12, 13, and 14; Astronomy, Mr. A. R. Hinks, October 18, 19, 20, and 21; and Geometry, Mr. W. H. Wagstaff, November 7, 8, 10, and 11. The lecture-hour is 6 o'clock.

THE Prospectus of University Courses in the Municipal College of Technology, Manchester, for the session 1921–22 has recently been issued. Systematic training extending over a period of three or four years is provided in mechanical, electrical, municipal, and sanitary engineering, the technology of the chemical and textile industries, photography and printing, etc. University courses leading to the degrees of Bachelor and Master of technical science in these subjects are available, and, in addition, there are numerous part-time day and evening courses for the benefit of engineers, apprentices, and others who cannot attend for full-time instruction. In conjunction with the Students' Union there is a technical section consisting of the Chemical, Engineering, and Textile Societies, the objects of which are to discuss technical subjects of interest to the members and to arrange for periodical visits to works and factories. These visits serve to amplify the generous arrangements made in the college itself for practical work in the laboratories.

Calendar of Scientific Pioneers.

September 22, 1703. Vincenzo Viviani died.—The last pupil of Galileo, Viviani took a prominent place among the geometers of the seventeenth century, and became mathematician and chief engineer to the Grand Duke of Tuscany.

September 22, 1874. Jean Baptiste Armand Louis Léonce Elie de Beaumont died.—Professor of geology in the Collège de France and successor to Arago as permanent secretary of the Paris Academy of Sciences, Elie de Beaumont had a leading share in the geological survey of France, and among his best-known works are those relating to the age and origin of mountain systems.

September 23, 1738. Hermann Boerhaave died.—The most famous physician of his day, Boerhaave as a professor of botany, medicine, and chemistry raised the University of Leyden to the summit of its fame. His writings were translated in many languages.

September 23, 1877. Urbain Jean Joseph Leverrier died.—Sharing with Adams the honour of the discovery of Neptune, Leverrier was one of the greatest French astronomers of last century. He succeeded Arago as director of the Paris Observatory, where he carried out the complete revision of planetary theories and the formation of new tables.

September 23, 1882. Friedrich Wöhler died.—Born in 1800, Wöhler while a teacher in the Berlin Trade School first prepared the metal aluminium, and in 1828 effected the synthesis of urea. He collaborated with Liebig, and, like him, was a great teacher. From 1836 he held the chair of chemistry at Göttingen.

September 24, 1541. Paracelsus died.—A remarkable figure in the annals of science, Paracelsus—or Theophrastus Bombastus von Hohenheim—was the contemporary of Copernicus and Luther. An erratic genius of extraordinary insight, but notorious habits, he was a leader in the revolt against authority which marked the beginning of modern scientific progress.

September 25, 1777. Johann Heinrich Lambert died.—One of the group of learned men attracted to Berlin by Frederick the Great, Lambert enriched both mathematics and astronomy by his researches and discoveries.

September 26, 1703. Johann Christoph Sturm died.—Sturm has been called the restorer of the physical sciences in Germany. He was for many years at the Academy of Altdorf, and persistently advocated the introduction of science into the schools of Germany.

September 26, 1868. August Ferdinand Möbius died.—Holding the chair of higher mathematics and astronomy at Leipzig, Möbius was regarded as one of the leaders in modern projective geometry.

September 27, 1908. John Macon Thome died.—As assistant and successor to Gould at the Cordoba Observatory, Thome did much for astronomy in South America.

September 28, 1895. Louis Pasteur died.—Honoured as a benefactor of mankind, Pasteur was a great chemist and a great biologist. He was drawn to the study of chemistry by the lectures of Dumas, and became a professor first at Strassburg, then at Lille, and in 1867 at the Sorbonne. The Pasteur Institute in Paris contains his tomb, and his record of services is inscribed upon it thus :—

"1848, Molecular dissymmetry. 1857, Fermentations. 1862, Spontaneous generation. 1863, Studies on wine. 1865, Silkworm diseases. 1871, Studies on beer. 1877, Contagious diseases of animals. 1880, Vaccination against contagious diseases. 1885, Prevention of hydrophobia." E. C. S.

Societies and Academies.

PARIS.

Academy of Sciences, August 22.—M. Léon Guignard in the chair.—J. K. **de Fériet**: Hypergeometric functions of higher order with two variables.—R. **Serville**: The tangential and radial resistance of a turning body. Application to the isochronism of the conical pendulum by a central force.—K. **Ogura**: The movement of a particle in the field of a charged nucleus.—St. **Procopiu**: The depolarisation of light by liquids holding crystalline particles in suspension. Depolarisation is practically *nil* for pure liquids, very small for non-crystalline suspensions or for substances crystallising in the cubic system, and large for doubly refracting suspensions. A solution of ferric chloride is strongly depolarising, suggesting that the colloidal particles are crystalline and doubly refracting.—P. **Dejean**: The transformation of iron at the Curie point. From the experiments described it is concluded that the apparent discontinuity produced in the magnetic qualities at the Curie point can be explained by a continuous action, either the progressive transformation of an α form into a β form, or, more simply, the progressive separation of the elementary magnets by the gradual rise of temperature.—M. **Bridel** and Mlle. Marie **Braecke**: The presence of a glucoside hydrolysable by emulsin in two species of the genus Melampyrum. These plants blacken on drying, and this is shown to be due to the presence of a glucoside. This glucoside, on hydrolysis, gives a black insoluble substance. It is possible that the glucoside is aucubine.—M. **Bezssonoff**: The antiscorbutic principle in potato-juice extracted in presence of acids. The juice extracted from potatoes by pressure possesses a very small antiscorbutic action. As it was thought probable that the antiscorbutic principle might under these conditions have been destroyed by laccase, a small proportion of citric acid was incorporated with the potato before applying pressure. The acidity in the juice thus obtained was sufficient to inhibit the oxidising action of the laccase, and it was found that the antiscorbutic action of this expressed potato-juice was much higher than that expressed without the addition of acid.—J. **Mascart**: Weather forecasts for long periods.—J. **Politis**: The *rôle* of the chondriome in the defence of the plant against parasitic invasion.—H. **Ricome**: The orientation of the stem.—St. **Jonesco**: Anthocyanidines in the free state in the flowers and red leaves of some plants. Proof that this red pigment exists in the free state in red organs of plants.—A. **Kozlowski**: Saponarine in *Mnium cuspidatum.*

September 5.—M. Georges Lemoine in the chair.—S. **Banach**: Ensembles of points the differential coefficient of which is infinite.—J. **Grialou**: The irrotational and permanent movement of a liquid, the trajectories being vertical and plane and the *régime* permanent.—A. **Lumière** and H. **Couturier**: The relations between the anaphylactic shock and the introduction of precipitates into the circulation. The experiments of Arthus on the introduction of an emulsion of beeswax into the veins gave results which appear to contradict the physical theory of shock put forward by the authors. Additional experiments with the wax emulsion are described, showing that this can also cause anaphylactic shock if injected into the left ventricle of the heart. The authors regard the experiments of Arthus as affording additional confirmation of their views as to the cause of shock.—J. **Pottier**: Observations on the chromatic masses of the nuclei and of the cytoplasm of the cells of the canal and of the wall of the neck of the archegonium in *Mnium undulatum.*—N. **Bezssonoff**: A colour reaction common to antiscorbutic extracts and hydroquinone. The author describes a modification of the Folin-Denis phenol reagent which gives a blue coloration with plant extracts known to possess antiscorbutic power and no coloration, or colour not blue, with plant extracts devoid of antiscorbutic power. It is not regarded as proved that the blue colour is due to the antiscorbutic substance, since it may be caused by a polyphenol split off in solution from the vitamin C. Of the numerous phenols tested the only one giving the same blue colour proved to be hydroquinone.

EDINBURGH.

Royal Meteorological Society, September 7.—Mr. R. H. Hooker, president, in the chair.—R. H. **Hooker**: The functions of a scientific society, with special reference to meteorology. The main functions of a society are the discussion of discoveries, the formation of a library, and the printing of technical papers. In spite of the increase in Government institutions undertaking original scientific investigations, there are more scientific experts outside Government service than in it, and the latter find the society a necessary means of inter-communication in order to keep abreast of the times. The spread of science among the greatest number of people is one of the most important objects of the society. The recent amalgamation of the Royal and Scottish Meteorological Societies might appear to curtail the opportunities of Scottish fellows, but the present session in Edinburgh was intended to be the forerunner of others. Also, local meetings could be held at any centre where there were a sufficient number of fellows within reach.—Dr. A. **Macdonald**: Meteorology in medicine, with special reference to the occurrences of malaria in Scotland. The fundamental meteorological factor influencing biological reactions is temperature. This influence is universal in its application to organic life, and has specific implication in the production of disease. The *rôle* of temperature in the manufacture of diseases due to the parasitic protozoa is dealt with in a consideration of the temperature limitations of the development of the sexual phase of the plasmodia of malaria in the anopheline mosquito. The history of the occurrence of malaria (ague) in Scotland is studied in relation to temperature conditions that have prevailed since early in the eighteenth century. Actual recorded outbreaks are shown to coincide with abnormal high temperature over several months in consecutive years. Wars have been the main factor in the introduction of malaria infection, which, although powerless to establish the disease endemic in Scotland, will produce an outbreak when importation in large volume coincides with a mean temperature of 60° F. continued over a period.—Dr. A. Crichton **Mitchell**: The diurnal variation of atmospheric pressure at Castle O'er and Eskdalemuir Observatory, Dumfriesshire. The hourly values of atmospheric pressure recorded at Eskdalemuir Observatory during the ten years 1911–20 have recently been reduced, and a comparison with those obtained by Dr. C. Chree from the Castle O'er barograph records during 1902–8 show very considerable differences, although the stations are close together. These differences are probably due to unsuitable exposure of the Castle O'er instrument and to its imperfect temperature compensation.—Dr. S. **Fujiwhara**: The natural tendency towards symmetry of motion and its application as a principle in meteorology. "Any revolving system in Nature tends towards symmetry within the limit of its freedom." A special case of this principle is that "when any revolving fluid lies near to a plane boundary its axis tends to become normal to that boundary." Many examples supporting the above principle have been obtained from meteorological observations, and synthetically the universal existence of the above proposition is assumed. It is suggested that the present principle must be derived from "the principle of equality."—C. J. P. **Cave**: Some notes on meteorology in war-time.

Books Received.

An Experiment in Synthetic Education. By Emily C. Wilson. With Chart for Five Years' Work. Pp. 62. (London: G. Allen and Unwin, Ltd.) 4*s*. 6*d*. net.

Twenty-five Years in East Africa. By Rev. J. Roscoe. Pp. xvi+288+19 plates. (Cambridge: At the University Press.) 25*s*. net.

Treatise on Fractures in General, Industrial, and Military Practice. By Prof. J. B. Roberts and Dr. J. A. Kelly. Second edition, revised. Pp. x+755. (Philadelphia and London: J. B. Lippincott Co.) 42*s*. net.

Biological Chemistry. By Prof. H. E. Roaf. Pp. xvi+216. (London: Methuen and Co., Ltd.) 10*s*. 6*d*. net.

The Fourth Dimension Simply Explained: A Collection of Essays Selected from those Submitted in the *Scientific American's* Prize Competition. By Dr. H. P. Manning. Pp. 251. (London: Methuen and Co., Ltd.) 7*s*. 6*d*. net.

Geofysiske Publikationer, vol. 1, No. 1. The Position in Space of the Aurora Polaris, from Observations made at the Haldde Observatory, 1913–14. By L. Vegard and O. Krogness. Pp. vii+172+plates. (Kristiania: A. W. Brøggers.)

Annales de l'Observatoire astronomique de Tokyo. Tome 5, 4 fascicule: Studies on Astronomical Time-keepers and Time-preserving Systems. By Kiyofusa Sôtome. Pp. ii+59. (Tokyo: Imperial University.)

New Zealand. Department of Mines: Geological Survey Branch. Palæontological Bulletin, No. 8: Lists of New Zealand Tertiary Mollusca from various Localities Examined and Named from 1913 to the End of 1917. By H. Suter. Pp. vii+107. (Wellington.)

Die Tagebücher von Dr. Emin Pascha. Herausgegeben von Dr. Franz Stuhlmann. Band VI., Zoologische Aufzeichnungen Emin's und seine Briefe an Dr. G. Hartlaub, bearbeitet von Prof. Dr. H. Schubotz. Pp. viii+301. (Hamburg und Braunschweig: G. Westermann.) 200 marks.

The Advancement of Science: 1921. Addresses Delivered at the 89th Annual Meeting of the British Association for the Advancement of Science, Edinburgh, September, 1921. (London: J. Murray; The British Association.) 6*s*. net.

A Short Course in Commercial Arithmetic and Accounts. By A. Risdon Palmer. (Bell's Mathematical Series.) Pp. x+171+xv. (London: G. Bell and Sons, Ltd.) 2*s*. 6*d*.

The Use of Graphs in Commerce and Industry. By A. Risdon Palmer. (Handbooks of Commerce and Finance). Pp. ix+47. (London: G. Bell and Sons, Ltd.) 2*s*. net.

Practical Mathematics. By A. Dakin. Part 1. Pp. viii+362+12+xxiv. (London: G. Bell and Sons, Ltd.) 5*s*.

Index Kewensis Plantarum Phanerogamarum. Supplementum Quintum Nomina et Synonyma Omnium Generum et Specierum ab Initio Anni MDCCCCXI Usque ad Finem Anni MDCCCCXV Nonnulla Etiam Anteä Edita Complectens. Ductu et Consilio D. Prain, Confecerunt Herbarii Horti Regii Botanici Kewensis Curatores. Pp. iii+277. (Oxonii: E Prelo Clarendoniano.) 76*s*. net.

Memoirs of the Geological Survey. Summary of Progress of the Geological Survey of Great Britain and the Museum of Practical Geology for 1920. Pp. iv+112. (London: E. Stanford, Ltd.; Southampton: Ordnance Survey Office.) 3*s*. 6*d*. net.

Memoirs of the Geological Survey: Scotland. The Economic Geology of the Central Coalfield of Scotland. Area IX., Carluke, Strathaven, and Larkhall, with Braidwood, Netherburn, Auchenheath, Blackwood, and Stonehouse. By L. W. Hinxman and others. Pp. viii+148. (London: E. Stanford, Ltd.; Southampton: Ordnance Survey Office.) 8*s*. net.

The Continents of the South. By A. B. Archer. (A Secondary School Course in Geography, Book II.) Pp. xvi+272. (London: W. Heinemann.) 4*s*. 6*d*. net.

Soil Conditions and Plant Growth. By Dr. E. J. Russell. (Rothamsted Monographs on Agricultural Science.) 4th edition. Pp. xii+406. (London: Longmans, Green and Co.) 16*s*. net.

The Physical Properties of Colloidal Solutions. By Prof. E. F. Burton. (Monographs on Physics.) 2nd edition. Pp. viii+221. (London: Longmans, Green and Co.) 12*s*. 6*d*. net.

The Transition Spiral and its Introduction to Railway Curves: With Field Exercises in Construction and Alignment. By Arthur L. Higgins. Pp. viii+111. (London: Constable and Co., Ltd.) 6*s*. net.

Diary of Societies.

WEDNESDAY, SEPTEMBER 28.

FARADAY SOCIETY (at Institution of Electrical Engineers), at 4.30.—General Discussion on Catalysis, with Special Reference to Newer Theories of Chemical Action. Part 1, The Radiation Theory of Chemical Action, opened by Prof. J. Perrin. Part 2, Heterogeneous Reactions, opened by Prof. I. Langmuir. Expected speakers:—Prof. Arrhenius, Prof. V. Henri, Prof. E. C. C. Baly, Prof. F. G. Donnan, Prof. W. C. McC. Lewis, Prof. A. Lindemann, Prof. A. W. Porter, and Dr. E. K. Rideal.

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