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Research in Animal Nutrition.

THE recent munificent gift of 100,000*l.* made by Sir Alfred Yarrow to the Royal Society is a tribute to the service of science to industry from a great manufacturer. It is somewhat astonishing, however, how little money has been gifted for research work into agricultural problems, in view of the fact that animal husbandry, with the occupations that depend directly upon it, is the most important industry in this country, and that, in spite of the large home production of animal foods, it is still necessary to import to a value of more than 200,000,000*l.* per annum without even then meeting fully the demands for some of those animal products.

We are probably correct in stating that in no other industry has so little been done in Great Britain to develop the scientific side, to find out the most economical methods of feeding, to reduce the relatively enormous mortality among many kinds of stock, to investigate the true nutritive value of the raw materials of feeding stuffs and the processes by which they are converted into the commercial finished product. It is true that Rothamsted is a monument to a brilliant pioneer in agricultural research, but for long this institute stood practically alone. It was not until the establishment of the Development Commission in 1911, which was appointed with the object of developing rural industries, that any real effort was made to improve this disastrous state of things. The Commissioners came to the very rational conclusion that one of the most essential things was a national scheme of research in agriculture.

As the result of full inquiry the Commissioners determined to establish two centres for the study of animal nutrition, one at the School of Agriculture at Cambridge under Prof. T. B. Wood, and the other at Aberdeen in connexion with the North of Scotland College of Agriculture and the University of Aberdeen. At Cambridge advantage was taken of an already existing and excellent research organisation, which was assisted financially and developed. At Aberdeen, however, a new institution had to be established. The amount of the capital outlay was estimated at 40,000*l.* to 50,000*l.*, and of this sum 20,000*l.* was obtained from the Development Commission.

In spite of this splendid grant, if it had not been for the very public-spirited action of Dr. John Quiller Rowett, who promised an initial subscription of 10,000*l.* and a further contribution if necessary, it is probable that the establishment of the institute might have been delayed for years for lack of funds. It is fitting that the name of this generous donor, who was willing to support this experimental institute before its capacity to undertake research was proved, should be for all time associated with it. All who are interested not only directly in agriculture, but also indirectly in food production generally, are under a deep debt of gratitude to Dr. Rowett. It is pleasant to record that the example of Dr. Rowett has already stimulated an Aberdeen donor, Mr. Walter A. Reid, to give 5000*l.* towards the development of the library and the statistical department of the Rowett Institute.

The food troubles of the War ought to have brought it home to all that British agriculture was in a parlous state. Great Britain may be able to raise the finest horses and cattle in the world, but nevertheless our agriculture in general is in a backward condition. Sir Thomas Middleton before the war drew a most interesting series of comparisons showing the effect of the application of science between agriculture in Great Britain and in Germany, where the soil is inferior to ours. From each 100 acres of land the German farmer obtained 33 tons of corn to the British 15, 55 tons of potatoes to the British 11, 28 tons of milk to the British 17½, and even 4½ tons of meat to the British 4.

Research in Great Britain in other branches of science would have been in a poor state if it had had to rely in the past on support from public funds. We owe much of our outstanding position in various sciences to gifts from far-sighted private benefactors. Surely agriculture, which becomes the hobby of so many of our successful business men, ought to attract the necessary funds to assist in the investigation of problems of really national importance. There is abundant opening both at the Rowett Institute and at Cambridge for generous donors to assist, for example, by the institution of experimental farms on a large scale at these institutes. Such practical workshops as experimental farms are essential to demonstrate to the so-called "practical" agriculturist that there are ways better than his own of doing things, that will convince him, for example, that there is such a thing as the hygiene of the cowhouse and byre. Men talking and lecturing about the possibilities of doing things properly will not suffice; there must be actual demonstration of the value of the suggested change. The soil breeds an individual slow to convince, but facts tell. As Dr. Orr, the director of the Rowett Institute, has shown, even in the short time the work has been running at Aberdeen, such farms can be made to pay their way. The pig farm he established last year already shows a positive financial balance.

It must not be forgotten, too, that indirectly from these experiments on farm animals there will eventually emerge a great body of knowledge of direct use in the solution of human nutritional problems. Dr. Rowett, when conveying his donation to the Aberdeen Institute, definitely recognised this fact, and even stipulated that so far as possible the nutrition of man as well as that of animals should be kept in view.

As there is no institute or laboratory devoted to the investigation of the nutrition of man in Great Britain, these animal stations will have to be depended upon for a great deal of the information we now lack on mineral metabolism, to take a single outstanding example of a neglected field of study. We trust, therefore, that generous provision will be made for the maintenance and extension of the valuable research work on problems of nutrition being carried on at Aberdeen and Cambridge.

The King's English.

Notes on the Composition of Scientific Papers. By the Rt. Hon. Sir T. Clifford Allbutt. Third edition. Pp. xii+192. (London: Macmillan and Co., Ltd., 1923.) 6*s.* net.

SIR CLIFFORD ALLBUTT, the author of this little book, informs us in the preface that he has occasion in his capacity as a member of the Medical Faculty of the University of Cambridge to read, in the course of each academic year, some seventy or eighty theses which are presented for the degree of M.B. and about thirty which are offered for that of M.D. Of the value of such theses, as indicative of the prospective graduates' attainments or ability, there is a difference of opinion. Considering the usual age and opportunities of the candidates, and their limited professional experience, the theses are necessarily, for the most part, mere compilations culled from text-books, or from the records of cases in the medical journals. But, however limited their value, we are disposed to agree with Sir Clifford Allbutt that they serve a useful purpose. The search through the literature is of itself a salutary and desirable regimen. It serves to concentrate the student's attention on a single subject, and ends by making him a better informed man on that particular subject than he otherwise would be. Of course, much depends upon the choice of the subject. Sir Clifford's experience is that, on the whole, the candidates choose wisely. He tells us that the matter of these theses is good, often excellent. What he complains of is the manner of their presentation. In composition some are fair, and a few are good, but the greater number are written badly, some very ill indeed. "The prevailing defect of their composition is not mere inelegance: were it so, it were unworthy of educated men; it is such as to perplex, and even to travesty or to hide the author's meaning."

The purpose of Sir Clifford Allbutt's book is to direct attention to these faults of "style" and of literary composition, in the hope that candidates for medical degrees may avoid the many solecisms which their theses too frequently display. It is easy to see how they arise. The art of literary composition is seldom a part of the school training of a youth. If it is taught at all it is too frequently dealt with by a master who has no real aptitude for literary craftsmanship, whose knowledge of our literature is limited, and whose critical faculty is not very acute. To bring out the best that is in a boy, to "enthuse" him with the subject, requires a teacher of rare gifts, of wide reading, knowledge, and experience. It is far easier to teach mathematics, or the elements of physical science, or even such subjects as history or a modern language, than it is to inculcate the best method of handling such a rich and flexible language as English in written composition. The consequence is that literary composition occupies, as a rule, a very subordinate position in the curriculum of a school, and the youth enters upon his higher education or even upon his life's work with a very limited experience of the richness and beauty of his mother-tongue and with little or no knowledge how properly to deal with it.

Sir Clifford Allbutt's strictures are based mainly upon his experience of the graduation theses of medical students, but they are no less applicable to the composition of scientific papers in general. The man of science, as a rule, springs from the same class as that which furnishes the medical man, and their upbringing and scholastic training are identical. It is therefore to be expected that they should both suffer from the same disabilities. Hence the author is fully justified in the selection of the more comprehensive title which he has attached to his work. A very limited experience of the periodical literature of science affords ample proof of the relevancy of his criticisms. Scientific memoirs are too frequently mere transcripts of laboratory journals, with no proper attempt at selection, logical arrangement, economy of expression, lucidity, unity, or simplicity—the cardinal virtues which Sir Clifford Allbutt rightly insists should characterise all literature.

The book is evidently the result of much careful study of contemporary scientific literature, and it is replete with illustrations and examples of faults in literary composition to be found in scientific communications. The author's criticism is in the main constructive. If he points out a solecism, as a rule he shows how it should be avoided. At times, although he would doubtless deprecate the implication, he appears to be a little hypercritical and over-fastidious, and some exception might justly be taken to his ruling. The fact is the English language is not standardised, and it is contrary to its genius and to its progressive nature that it should be. Its character is largely determined by use and wont, and by the example and influence of the acknowledged masters of literary craftsmanship. There is no established standard of style. "The style is the man." The styles of Johnson and Addison, of Ruskin and Carlyle are as wide apart as the poles: they are individualistic and characteristic of the men. It is this variety which serves to make our language the noble instrument that it is.

He who constitutes himself a literary censor, and takes up an *ex cathedra* attitude in the matter of literary composition, especially in the case of a language such as English, needs to be very sure of his ground and to walk warily. Years ago a certain Dean of Canterbury was constrained to publish a little book on the "Queen's English." That book was somewhat pitilessly handled by Mr. Washington Moon in a rejoinder entitled the "Dean's English." This episode should be a warning to those who would rush in where angels may well fear to tread. Sir Clifford Allbutt has certainly the courage of his opinions and is not slow to tell us of his likes and dislikes, but even he, like the great Homer himself, sometimes nods, and lays himself open to rebutting criticism. At the same time, his book is well worthy of the attention and careful study of all who seek to write correctly, and with a pious regard to the splendid inheritance they possess in their mother-tongue.

Eastern Tibet.

Travels of a Consular Officer in Eastern Tibet: together with a History of the Relations between China, Tibet, and India. By Eric Teichmann. Pp. xxiv+248+64 plates+8 maps. (Cambridge: At the University Press, 1922.) 25*s.* net.

EASTERN Tibet remains the least known part of Asia in spite of its exceptionally interesting problems. An important contribution to its geography has now been made as one of the indirect results of the British expedition to Lhasa in 1904. The Chinese then feared the annexation of Tibet to India, and to avert this danger immediately sent an agent to Eastern Tibet; in the following year, this "Amban" and his escort were massacred, and several French missionaries were murdered at their stations along the Tibetan frontier. To suppress the revolt Chao-erh-feng invaded the country, and Chinese authority was established and agents reinstalled in Lhasa.

Chao-erh-feng was a man of remarkable capacity, and he secured the personal trust of the Tibetans by a policy which protected them from the tyranny of the lamas, and by the severity with which he punished any ill-conduct by his own soldiers. During his rule the Chinese position in Tibet was secure. When the Manchu Dynasty was tottering he was recalled eastward and made Viceroy of Szechuan. He was executed in Cheng-fu, the capital of that province, by the revolutionists in 1911, after a heroic effort to maintain the old government. The author fully recognises the genius of Chao-erh-feng, whom he describes as "one of China's greatest Empire builders," and says that "with him passed away Chinese ascendancy over Tibet." He adds that Chao-erh-feng's justice and fair dealing are still remembered. This tribute to the great Chinese administrator is the more weighty as the author's sympathies are rather pro-Tibetan.

After Chao-erh-feng's death Chinese rule in Tibet promptly collapsed. The Tibetans in 1912–13 recovered most of the lost country, and after a five years' truce resumed their eastward advance in 1918. There was then no Chinese force available for the defence of Western China, but there can be little doubt that if the Tibetans had seized some of the territory they coveted, the Chinese would reconquer it as soon as the internal difficulties in China are smoothed down. To avoid a prolonged war between Tibet and China, the British Government used its influence to secure a peaceful settlement. Mr. Eric Teichmann, then the British Consul at Ta-tsien-lu, acted as the local mediator, and in this volume he tells the story of the Tibeto-Chinese war and negotiations, and describes the journeys he made during his efforts to arrange peace. By great tact and patience he persuaded both sides to accept a temporary arrangement which may be ultimately adopted without loss of prestige to either side. He induced them to revert to the frontier which had been recognised from 1727–1905. During these negotiations Mr. Teichmann had exceptional opportunities for travel in unknown parts of Eastern Tibet. He is an enthusiastic and capable geographer, and made the best of his chances. The volume in which he records his experiences and observations will remain one of the standard works on the geography of East Central Asia.

The district including most of his routes lies north of the Ta-shueh-shan or Great Snow Mountains, which rise on the northern side of the famous road from China to Lhasa. From the foot of these mountains extends a vast tract of down country about 13,000 ft. above sea level; it is dissected by valleys from 2000 to 3000 ft. deep, and rises into high snow-covered ranges of which the heights and relations are unknown. Mr. Coales, the author's predecessor at Ta-tsien-lu, has shown that the country is largely composed of red sandstone and limestone. This view is confirmed by Mr. Teichmann; but there is no evidence as to which of four possible series this limestone belongs, and without further information as to the geological structure and trend of the snow-capped mountains, the fundamental structure of the country remains uncertain. Mr. Teichmann's careful observations are the more useful owing to the excellent index. There are numerous photographs, a series of seven sketch maps, and a large map of Eastern Tibet reprinted from the *Geographical Journal*.

J. W. G.

Hereditary Diseases of the Eye.

University of London: Francis Galton Laboratory for National Eugenics. Eugenics Laboratory Memoirs, 21. *The Treasury of Human Inheritance.* Vol. II.: Anomalies and Diseases of the Eye. Nettleship Memorial Volume. Part I.: Retinitis pigmentosa and allied diseases; Congenital stationary night-blindness; Glioma retinæ. By Julia Bell. With a Memoir of Edward Nettleship by Dr. J. B. Lawford. Pp. xv+123+26 plates. (Cambridge: At the University Press, 1922.) 45*s*. net.

ALL students of genetics will welcome the resumption of publication of "The Treasury of Human Inheritance," interrupted, like so many other scientific researches, by the War. Prof. Karl Pearson has now been able to issue Part I. of the Nettleship Memorial Volume, devoted to retinitis pigmentosa and allied diseases, congenital stationary night-blindness, and glioma retinæ. The report on and pedigrees of these diseases is preceded by a memoir of Edward Nettleship, written by his old colleague, Dr. J. B. Lawford. Nettleship was a fine example of the combination of clinician and researcher, which, to the honour of British medicine, has been frequent in this country and perhaps especially frequent in the department of ophthalmology. Dr. Lawford has well brought out Edward Nettleship's sterling qualities, which added lustre to a family distinguished in the fields of pure scholarship and philosophy. Nettleship possessed, to a very eminent degree, the patience, powers of observation, and natural sagacity which are essential to success in the investigation of problems of inheritance. His career adds one more to the numerous proofs that arduous medical practice is no barrier to distinguished success in pure science.

The composition of the work was entrusted to Dr. Julia Bell, who has acquitted herself admirably. The discussion of the genealogical material is preceded in each case by an historical and anatomical account of the anomaly in question which, while scientifically adequate and strictly impartial, is intelligible to the educated layman. The pedigree plates maintain the very high standard of achievement set by former publications of the Galton Laboratory. With the exception of glioma retinæ—a rare and malignant disease—few of the conditions here dealt with threaten life, while nearly all of them so greatly interfere with the comfort of existence—in some cases making it impossible for the victim to follow his profession—that their recognition is frequent. It would therefore be expected that a large amount of genealogical material should be available. Such is the case, but the absolute frequency of the diseases is small, and in many instances, such as that of the classical Nougaret family, victims are by no means anxious to reveal their disability to strangers.

It is particularly appropriate that the volume should be dedicated to the memory of Nettleship, for a large share of the material relating to retinitis pigmentosa and the lion's share of the data of congenital stationary night-blindness are the product of his own researches.

"The Treasury" is planned to be a storehouse of facts, so that no complete analysis of the data is attempted; but certain interesting points are made. Attention is specially directed to two: (1) the presence of other defects in the family histories, (2) the etiological importance of consanguinity. As to (1), it would seem that each of these defects tends to occur largely as a single defect, but that if retinitis pigmentosa is associated with deafness in the stock the link is a close one. With respect to (2), consanguineous marriages are far more common in the diseased stocks than in the general population, save in the case of that form of congenital stationary night-blindness which is limited to males. In only one case, however, does the proportion of affected offspring of consanguineous marriages seem to exceed materially that found among the offspring of non-consanguineous marriages, a result differing from what has been observed in the records of deaf-mutism and albinism.

The very rare and usually fatal anomaly, glioma retinæ, scarcely lends itself to statistical treatment. However, in view of its absolute rarity—it is estimated not to furnish more than 0·03 per cent. of all patients suffering from diseases of the eye—the fact that it has been possible to compile thirty-six histories showing more than one case in a stock is strong evidence that this, too, is an hereditary defect.

In a prefatory note, Prof. Karl Pearson thanks the Medical Research Council for a grant in aid of the work, and expresses a "hope that the work as completed will be considered to have justified their support." The scientific public will have no doubt on that score; there could be few objects more worthy of national support than the preparation of scholarly and impartial records of the facts of human inheritance. Dr. Bell has, in our opinion, produced a thoroughly satisfactory monograph, which will at once take rank as a standard work while being—a quality by no means to be predicated of all standard works—adequate from both the literary and the artistic points of view.

Chemical and Physical Tables.

Tables annuelles de constantes et données numériques de chimie, de physique et de technologie. Vol. IV.: Années 1913–1914–1915–1916. Première partie. Pp. xxxii + 626. Deuxième partie. Pp. xxxv + 627–1377. (Paris: Gauthier-Villars et Cie.; London: Cambridge University Press; Chicago: University of Chicago Press, 1921–1922.) 2 parts, 7*l.*

FOR reasons which are not very clear, the earlier volumes of the "Tables annuelles" have not been fully used in this country; but a cursory inspection of Volume IV. will give the physico-chemical doubter cause to think, while an hour's serious use of it will convert him completely. Which of us can lay his hand on his heart and say that he has missed nothing essential to his subjects of research? Let him open these volumes and—unless he has already consulted them—he will be humbled. Landolt-Börnstein carries us up to the end of 1911; from that time onwards, no indexes or abstracts, however complete of their kind, afford a sufficient guide to the seeker after data, who must nowadays add to his scientific equipment the faculties of a British Museum historian and the time in which to exercise them.

There are here recorded the classified, clearly indexed data amassed during four years from 340 periodicals and other sources by 32 abstractors in 19 countries, collated by 27 well-known compilers who are specialists, and edited by Dr. Charles Marie (to whose devotion and enthusiasm the "Tables annuelles" so largely owes its existence and its success). The general control is vested in an executive of eight eminent physical chemists from a powerful international committee representing 23 nations.

It is obvious that to neglect the output of such an organisation as this would be sheer waste. In the writer's opinion (formed in spite of a hitherto somewhat inert attitude towards the earlier volumes) there is no library of physics and chemistry, pure or applied, which can now afford to be without this publication. The price seems high at first sight; but it is an investment which will repay itself many times, even before the next volume appears.

In the plan of the work much has, naturally, been gained from Landolt-Börnstein, but the scope is considerably wider and at the same time more detailed.

A series of practical tests in various sections shows that it is easy to trace at once the information sought; and to this end a system has been adopted in which rigidity has been tempered very wisely. There are chapters in Part II. which one might have expected to be placed near others in Part I.; for example, thermochemistry is separated from thermodynamics in this way, and cryoscopy from vapour pressures; but some change in the sequence of sections may doubtless be made hereafter, and in the meanwhile there is no obstacle to utility. The printing is clear; and with the tabulated data the compilers give sufficient indication of the experimental method used, mention any general formulæ found applicable by the author, and state the conditions quite unambiguously. The use of graphs instead of tables in dealing with subjects such, for example, as absorption-spectra, equilibrium mixtures of metals, or the ignition of gaseous mixtures, is well carried out. In chapters treating of organic compounds Richter's classification is used; and it is clear that the vexed question as to the organic or inorganic nature of calcium carbide would present no difficulty to the editor, for he provides the useful category of "Corps mixtes." This name, however, although no doubt correct in French, should certainly not be rendered in English as "mixtures." The misspellings of English authors' names are probably not more frequent than can be matched in English references to foreign literature.

Dr. Marie prints his regrets that this volume, covering 1913–1916, is only now issued; but, as in the case of Dr. Johnson's dog, the marvel is, not that it is done so well, but that it is done at all; for the difficulties during and just after the War must have been very great. That these difficulties have been passed, so that we have Volume IV., are informed of an accelerated issue of Volume V. (1917–1921), and may look for a regular progression thereafter, is a real achievement in advancing research. I. M.

Our Bookshelf.

Modern Tunneling. By David W. Brunton and John A. Davis. (New Chapters on Railroad Tunneling, by J. Vipond Davies.) Second edition, revised and enlarged. Pp. x+612. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1922.) 33*s*. net.

THE first edition of this work was published in 1914, and its contents were limited to mine and water-supply tunnels. The present edition has been revised and enlarged by Mr. John Vipond Davies, and contains new matter dealing with large-sized tunnels. The early part of the volume contains a very good discussion on the plant required in the construction of tunnels, and includes such subjects as the factors influencing the choice of prime movers, types of air compressors, surface plant generally, and methods of ventilation. This is followed by critical descriptions of the various underground appliances, such as rock-drilling machines, the methods of blasting, haulage, etc. The great development of tunnels during the last fifty years has been due to the application of high explosives and rock-drills, and this part of the subject receives adequate treatment. Details of the cost of a large number of tunnels are included, together with the speeds attained in driving them. There are two comprehensive bibliographies, and these may be regarded as an essential feature in a book on this subject and of moderate dimensions. The matter is presented in a very readable manner, and the volume will be of service not only to the engineer engaged in practice but also to the student of civil engineering.

La Force motrice électrique dans l'Industrie. Par Eugène Marec. Pp. viii+613. (Paris: Gauthier-Villars et Cie., 1922.) 55 francs.

M. MAREC's book is written for those who, having a sound theoretical knowledge, are more concerned with the choosing and installing of electrical machines than with the manufacture of them. The operation of the finished machine is discussed mainly by describing its characteristic curves. The engineer is thus enabled to judge which type of machine will prove the most useful for the particular purpose he has in view. The various methods of installing electrical machinery in a workshop are fully described. The book will be of use to the English engineer, as it will show him the best modern French practice, and it will be helpful for him to compare it with his own. The various French methods of charging for alternating-current power will interest him. One method is to charge the consumer for the watt-hours he has consumed. In addition a further charge is made for the magnetising hours, this further charge only being zero when the consumer uses apparatus the power factor of which is unity. The latest French rules for standardising apparatus and methods in electrical engineering are given. The comparison of them with the American and English rules is instructive.

Orographical, Regional, Economic Atlas. Edited by T. Franklin. Part 4: Africa. Pp. 32. (Edinburgh: W. and A. K. Johnston, Ltd.; London: Macmillan and Co., Ltd., n.d.) 1*s*. 6*d*. net.

THIS collection of forty-seven diagrams and maps of Africa and parts of Africa is wonderfully good value. It includes a coloured orographical map of the whole of Africa and sectional maps of the same on enlarged scales. A uniform scale for these sectional maps would have been an advantage. The maps appear to be accurate and revised to date. The allocation of the Cameroons to the League of Nations on one map is apparently a slip. The atlas deserves a wide use.

The All-Electric Age. By A. G. Whyte. Pp. xiii+242. (London: Constable and Co., Ltd., 1922.) 7*s*. 6*d*.

MR. WHYTE gives an interesting and accurate account of the latest electrical developments. He has refrained from speculating about the future, but we think that if he had pointed out the directions in which advances will probably be made he would have added to the interest of the book.

Letters to the Editor.

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

The Cause of Anticyclones.

IN reply to Major Goldie's letter in NATURE of March 31, p. 429, the following figures may be of interest.

Defining an anticyclone as a region where the barometric pressure exceeds 30·20 inches (1022·7 mb.), there are 52 cases of anticyclones in the British Isles during the years 1909 to 1922 inclusive in which the results of registering balloon observations are available.

Expressed as a departure from the mean for the height and date, these 52 cases give +1·6° F. at 1 km., +4·5° F. at 2 km., and +5·6° F. at 3 km. for the mean departure in an anticyclone. At 1 km. there are 18 negative values, at 2 km. there are 16, and at 3 km. there are 13. Ten instances, or only about one in five, show negative departures at each height.

For cyclones with a barometer reading below 29·40 inches (995·6 mb.) the corresponding mean figures are -6·1° F., -8·3° F., and -9·7° F., with 3, 2, and 1 positive signs respectively, out of 27 cases.

The above figures, the results of observations published by the Meteorological Office, do not seem to me to point to the conclusion that in England anticyclones are formed by pockets of cold polar air, but another test is available.

As I understand the theory of the Polar Front, polar air should be cold and have a low relative humidity; cold because it comes from a colder latitude, and dry because it is gradually warming up without a fresh supply of water and hence has a decreasing humidity. Conversely, equatorial air should be warm and nearly saturated. Where, then, polar air lies under equatorial air and forms a discontinuity, the inversion of temperature should be associated with an increase of relative humidity in the upper layer. Actually, just the reverse is the case.

I have examined the published figures for the continent, where records of the humidity are available for the years 1910 and 1911 separately; both years are consistent, and the combined result of nearly 300 observations is as follows :—

Percentage value to the nearest digit of observations in which an increase of relative humidity accompanies a temperature inversion, 0 per cent. Cases of inversion with no appreciable change of humidity, 4 per cent. Cases with distinct decrease, 36 per cent. Cases with very distinct decrease, 22 per cent. In these results both surface inversions and those over 3 km. are excluded.

Since the figures are not published on a homogeneous plan, classification is difficult, but "No appreciable change" means 5 per cent. or under, and 'Distinct decrease" means a fall of 20 per cent. or more.

One solitary instance of an increase of humidity exceeding 5 per cent. (it was 6 per cent.) was found; it occurred at Vienna on December 6, 1911.

The continental figures are fully supported by many hundreds of kite ascents in England, and they prove that cases of warm damp air overlying colder and drier air are practically non-existent.

Thus it appears from the abundant observational material available that the lower layers of the atmosphere are almost always cold in a cyclone, and are usually (three cases out of four) warm in an anticyclone; also that when an inversion of temperature occurs it is nearly always associated (58 cases out of 62) with dry rather than damp air above.

W. H. DINES.

Benson, Wallingford.

Hypotheses of Continental Drift.

IN many recent discussions of Wegener's theory and of other geological hypotheses, the assumption has been freely made that any force, however small, can deform the earth to any assignable extent if only it acts long enough. To declare that this assumption is incorrect is scarcely possible, in the absence of much more accurate knowledge of the physical conditions within the earth than we at present possess; but there is substantial evidence against it.

We believe that mountains have stood for millions of years, indicating that the rocks at their feet can endure for that time stress-differences equal to the pressure at sea-level in the middle of a mountain. The strength of rocks at depths of 200 to 400 km. is almost certainly less, but no geodetic observations indicate that the strength is insufficient to support an uncompensated hill 200 metres in height; inequalities greater than this appear on the whole to be compensated, but the unexplained gravity anomalies remain almost the same whether we suppose that inequalities less than 200 metres in height are compensated or not. Other data, however, indicate that isostasy is not always perfect: Dr. Morley Davies has pointed out one, and I have shown that several otherwise uncoordinated data can be coordinated on the hypothesis that the rocks in the asthenosphere, though weaker than those near the surface, have a finite permanent strength. Accordingly, the hypothesis that the asthenosphere can be deformed to an unlimited extent by any small force acting for a long time is one to be regarded with great suspicion, and not to be accepted until it has been proved that it will account for more than appears to be explicable on the contrary hypothesis.

In conjunction with this hypothesis another is often utilised, which can be definitely stated to be inconsistent with physical knowledge: namely, that such a small force can overcome a much larger force acting for the same time in the opposite direction. In Wegener's theory, for example, not only is a small force supposed to have moved America across the Atlantic, but also the resistance of the ocean bottom to deformation is supposed to have caused the elevation of the Rocky Mountains. Now, given a sufficiently weak asthenosphere and enough time, it would be possible to twist the outside of the earth over the inside to any extent. So long as the layers of equal density remained symmetrical about the polar axis, no elevation or depression of rocks taking place, deformation could proceed undisturbed, America going steadily on its way without mountain-building or any other phenomenon observable by geologists. In order that mountain-building may take place, however, energy must be supplied to raise and lower the rocks affected against gravity; and to keep them in position, in spite of the tendency of gravity to restore the symmetrical form, the force required must be enough to overcome gravity and the strength of the surface rocks. The minimum stress needed to account for mountain-building is therefore greater than the pressure due to the weight of the mountain. Tidal friction and differences between the values of gravity at the tops and bottoms of continents are capable of producing stresses of the order of 10^{-5} dynes per sq. cm., whereas to elevate the Rockies something like 10^9 dynes per sq. cm. would be required.

A hypothesis that may be of use in accounting for continental drift, if the latter is considered to be indicated by the geological evidence, is based on Jeans's proof (Proc. Roy. Soc. 93, 1917, 413-417) that the earth is stable with regard to first harmonic deformations. The fact that most of the land is in one hemisphere indicates that a first harmonic deformation exists, and must therefore be tending to die down; the only possible means of destroying the asymmetry being for the continents to break up and spread out so as to get as far apart as possible. If, then, we are prepared to admit that the continents were once all united into one mass, it is probable that they would have broken up and separated widely, since the stresses in them must have been comparable with the pressure at sea-level due to the weight of a continent, which is at any rate a moderate fraction of the strength of rocks. Wegener's suggestion that India has moved towards the main mass is, of course, inconsistent with this hypothesis.

The possibility that the continents were formerly united has been regarded by Mr. Crook (NATURE, February 24, p. 255) as in harmony with Osmond Fisher's theory of the origin of the Pacific. The latter theory, however, is open to a serious objection. The birth of the moon on the resonance theory would require a violent distortion of the earth, sufficient to shatter into fragments any crust that might have already been formed, and these would distribute themselves symmetrically over the liquid interior at once instead of waiting a thousand million years to do it.

Prof. Sollas's suggestion, mentioned by Dr. Evans in NATURE of March 24, p. 393, that there are traces in the earth of the incipient formation of a second satellite, is not in quantitative accordance with the resonance theory of the origin of the moon. It is practically certain that the earth-moon system, when combined into one body, did not rotate sufficiently fast for instability, but it is just possible that it could have rotated fast enough for resonance to magnify the solar semidiurnal tide to such an extent as to rupture the mass into two parts. If the moon was formed in this way, however, it must have taken away with it so much angular momentum that the earth could never again have approached conditions suitable for either resonance or instability.

HAROLD JEFFREYS.
St. John's College, Cambridge.

The Life-Cycle of the Eel in Relation to Wegener's Hypothesis.

THE argument in Dr. Wemyss Fulton's very interesting letter in NATURE of March 17, p. 359, must be divided into two parts. First, it is pointed out that the gradual recession of the east and west coast-lines of the North Atlantic Ocean from one another would explain in a very satisfactory manner the evolution of the amazing migrations of the larval eel. Secondly, it is assumed that Wegener's continental drift is the only method of effecting that gradual recession. It is possible to concur heartily with the first thesis, without admitting the second.

Suess explained the North Atlantic Ocean as having been formed, during the later ages of the Cainozoic era, by successive foundering of portions of a pre-existing land surface. Except that the recession of the two coasts would then have been spasmodic instead of continuous, the general result from the point of view of the inhabitants of the sea would be just the same as if the two continents were drifting apart. While acknowledging our indebtedness to Dr. Fulton for pointing out how the life-history of the eel fits in with the other evidences of a gradually widening Atlantic, we need not admit that these wonderful migrations prove continental drift any more than the migration of birds across the Mediterranean proves that Africa has drifted away from Europe.

A. MORLEY DAVIES.
Imperial College of Science and Technology,
South Kensington, S.W.7,
March 19.

The Combination between Oxygen and Hæmoglobin, and the Criteria of Adsorption.

HÆMOGLOBIN combines with oxygen approximately in the ratio of 16,670 to 32, by weight, as was shown by Peters (*Journ. of Physiol.*, vol. 44, p. 131). It is clear, then, that in solution the particle of hæmoglobin is very much larger than the particle of oxygen which combines with it. If one might assume that the densities and shapes of the particles were similar, then their surfaces would be in the ratio 64 to 1; in any case, and whatever the degree of aggregation of the particles, probably only a very small part of the surface of the hæmoglobin particles can be actually covered by oxygen when combination ceases at the stage of oxy-hæmoglobin.

This shows that the attraction of hæmoglobin for oxygen is a highly localised property of the hæmoglobin particles. For if this attraction were more or less evenly distributed over the surface, it would be satisfied only to a small extent, when a small part of the surface was covered, and at higher concentrations of oxygen than those which are found experimentally to give saturation with oxygen, more oxygen would be taken up.

Taking the thermal motions of the particles into account does not affect this argument, since the movements of the particles according to the laws of the kinetic theory do not affect their surface areas.

Now, if the attraction of hæmoglobin for oxygen is of such a character that it is satisfied when only a small portion of the surface is covered, it seems impossible to regard this combination as a case of adsorption.

The criteria of adsorption are perhaps not yet so well defined as could be wished, if differences of opinion as to whether a given process should be classified as adsorption or not are to be avoided. I am inclined to think that a process is rightly classified as adsorption, *if the substance taken up by the surface continues to be taken up until the whole surface is uniformly covered*, but not otherwise. Covering the surface uniformly is of course meant in the sense in which a gas or homogeneous solid is said to fill space uniformly; that is, uniformly to a being armed with a microscope to which individual atoms are small.

This definition is both definite theoretically, and in accordance with common conceptions of adsorption. It is difficult, indeed, to see what other definition is possible in the present state of knowledge. It is perhaps, however, desirable to state the definition clearly; although, as I feel it must have been present, whether formulated or accepted as self-evident, to the minds of many workers on adsorption, no sort of novelty is claimed for it here.

A definition of adsorption based on the nature or quality of the forces attracting the adsorbed substance, is now impossible, since it appears proved by Langmuir's work that there is no difficulty in accounting both qualitatively and quantitatively for many cases of adsorption, by means of the already very familiar forces which cause combination between metals and oxygen to form oxides, or the forces which bring about solution.

Obviously adsorption cannot be defined as "that which occurs at the surface of a colloid"; since colloids themselves are not yet a well-defined class of substances, and indeed the best studied cases of adsorption are at plane interfaces, not at the surfaces of colloids.

With the definition of adsorption proposed, a process would be excluded if, as with hæmoglobin and oxygen, combination occurs only at some defined locality on the surface. Similarly, the ordinary reactions of organic chemistry will be excluded, as they should be, since the substances taken up go to definite atomic groupings in the molecule. The combination of oxygen with hæmoglobin is seen to belong to the same class as most organic reactions.

It remains to examine whether the definition is practically applicable to known cases of adsorption, as well as theoretically justified; and whether, in the case of oxygen and hæmoglobin, the arguments originally put forward in support of the adsorption process are cogent enough to override the definition.

All cases of adsorption, from a gaseous phase, or from solution, on plane, or nearly plane, interfaces, are obviously compatible with the definition, since the common method of calculating the amount of adsorption assumes uniformity of distribution on the surface, and the results are generally expressed per sq. cm. of interface.

In the cases of adsorption on colloidal surfaces, when the extent of surface is usually not known, and the adsorption is expressed per gram of adsorbent, the definition is probably also applicable. Mecklenburg (*Zeitsch. f. physikal. Chemie*, vol. 83, p. 622) described experiments showing in several cases that the adsorption on different specimens of the same adsorbent, prepared, however, under different conditions, varied in a precisely similar way with concentration for each adsorbent, but the total amount adsorbed per gram was proportional to a factor in each case, this factor being presumably proportional to the area of the adsorbent.

In proposing the theory that the oxygen in oxyhæmoglobin is held by adsorption, Wo. Ostwald (*Koll. Zeitsch.*, vol. 2, pp. 264, 294) based the argument on two supposed facts: first, that no definite saturation point of oxygen with hæmoglobin could be found, a fact now shown to be incorrect; and, second, that the amount of oxygen taken up at different pressures could be fairly accurately represented, under certain conditions, by the so-called "adsorption isotherm," $y = kc^n$ (y = amount taken up, c = concentration of oxygen).

The mere fact that the variation of the amount taken up fits the "adsorption isotherm" does not seem now to be a sufficient ground for classing a process as adsorption. The "isotherm" has, until quite recently, been an empirical fact without theoretical explanation; and not only does it contain two independent arbitrary constants, which makes the fitting of a set of experimental data easier than would be the case otherwise; but also it is, at the best, usually only accurate at low concentrations, divergences being found at higher concentrations.

A more accurate equation relating amount adsorbed to concentration has been deduced recently (Henry, *Phil. Mag.*, vol. 44, p. 689, 1922) on the assumptions of a small range of molecular attraction and a monomolecular adsorbed layer, using well-established equations of the kinetic theory; and the author also gives a derivation of the "adsorption isotherm" on theoretical grounds. It would seem undesirable, however, to use the form of the relation between amount adsorbed and concentration as a criterion of adsorption, for this relation can never be a very simple conception, depending as it does on so many factors; but nothing could be simpler than to conceive of a surface as possessing either localised or diffuse attraction for a substance it takes up. It may be that in some instances it is not yet possible to form any estimate of the fraction of the surface covered; yet as accurate knowledge of the dimensions of molecules and of their orientation on surfaces accumulates, the applicability of the criterion here suggested will increase. I have tried to show, however, that it is already more generally applicable than any other.

N. K. Adam.

The University, Sheffield, March 6.

Labour and Science in Industry.

The article by "F. S. M." under this heading in Nature of March 24, p. 385, emboldens me to inquire whether the time has not come for a really searching scientific re-examination of the natural fundamental basis of the economic system under which we perish. That it is necessary to ask such a question as that in this article, whether, after a century's unparalleled progress in the domination of the forces of Nature and the fertile labours of inventors and producers, the average lot of the people is really better than it was in consequence, suggests a certain lack of scientific imagination. The question which many thoughtful people are now asking themselves, and which a few scientific men at least should have asked before the War, is not whether the material lot of the people is up to what it was before the use of science, but why is it not vastly improved. What kind of a civilisation ought to be the result, if science were directed in accordance with natural laws to the constructive purposes of life, rather than only so for the purposes of mutual destruction? Civilisation can scarcely revert in peace-time to economic law, in which the tokens of wealth usurp the place of reality, without raising the very general aspiration that the advantages of war and peace might be combined by proceeding according to natural laws in peace-time.

The first economists, the French Physiocrats, did make an effort to base their system on the laws of Nature, and in their doctrine, that the origin of wealth was the land, and in the later doctrine of Marx, that it was in human labour, certain obvious elements of natural truth were embodied. But in the present system there is no natural truth obvious at all. It is an offence against common sense. The production of wealth to-day is a relatively finished science, in which probably little that is fundamental remains unknown; whereas a century ago it was an empirical art as different from the present science as astronomy is from astrology or chemistry from alchemy. But the science of distributing the product—that is, the science of token wealth—is so little understood that the most incredible consequences are accepted as natural and inevitable.

In a natural community, if people were short of the necessities of existence, and knew how, they would produce and consume them. In ours, with the return to conditions of peace and victory, they are idle by the million and deteriorate mentally, morally, and physically, dumbly acquiescent in the requirements of a system no one pretends to understand. If one asks why, it is because of certain conventions with regard to bits of metal and paper to which we have all been born and brought up, but to which probably not one in a hundred, even among scientific men, has given two minutes' original thought.

The great clarification of ideas which distinguishes modern science, and especially physical science, ought not to stop short of this most vital and fundamental problem which so menaces the well-being of the community. It is, indeed, a most fascinating problem for its own sake. The mathematician would enlarge his knowledge of the consequences of a mistake in sign in a field where such mistakes are of fearful import to whole nations, and the physicist, of a perpetual-motion machine fallacy underlying and destroying the hopes, not of a half-crazy would-be mechanic, but of a half-crazy would-be mechanical civilisation. In his well-known book, "Instincts of the Herd," Mr. Trotter has put one obvious point inimitably. "It is this survival, so to say, of the waggoner upon the foot-plate of an express engine, which has made the modern history of nations a series of such breathless adventures and hairbreadth escapes." I venture to suggest that the survival of the herd-instincts of the waggoner in an express age applies as much to those who have built the express as to those who try to drive it.

The British Association naturally suggests itself as providing the proper platform for this proposed re-examination of the physical basis of our economic system, since it has an Economics Section which, no doubt, would welcome as eagerly as the public the introduction of an element of science into its proceedings. One needs to be only a casual observer of the trend of events to know that the public, thoroughly alarmed by the consequences of peace, and fearfully awaiting asphyxiation in the next war, would take an interest in this question that would rival that of the palmy days of Huxley and the Bishops.

FREDERICK SODDY.

WE shall all sympathise with Prof. Soddy's desire that our industrial system should give a state of society in which the material lot of the people should be "vastly improved" by the application of science. We should differ from him in various degrees as to the extent to which this has been already secured, and the means which should be taken to accelerate the process. I gave in the article quoted some reasons for believing that considerable improvement had taken place: it seems, in fact, untrue to say that "we are perishing" under our present economic system. The only country which can be said to have come near to "perishing" is Russia, which attempted entirely to discard the system and is now, after a desperate experience, painfully and slowly retracing her steps. The next most seriously distressed country in the world is China, which has never attained to our modern industrial system.

By all means enlist the Economics Section of the British Association in a discussion of the problem—or rather the host of problems—involved. But do not antagonise the Section at starting by suggesting that it would be a good thing to introduce "an element of science into its proceedings." The Section has been proceeding on that assumption for a good many years now.

F. S. M.

Tactile Vision of Insects and Arachnida.

WITH reference to Commander Hilton Young's suggestion noted on p. 409 of NATURE for March 24, it may possibly be of interest to record the conclusion at which I and my colleagues arrived, when engaged, two years ago, in research on the so-called eyes in insects and arachnida. In all the species studied, including the house-fly and red ants among the former, the house spider (*Tegenaria domestica*) and many of the Epeiræ among the latter, we were forced to the conclusion that the organs generally known as eyes do not act as organs of vision. What their main purpose is, was never *certainly* determined by us; but the many phenomena which were studied as evidence of sight could all be reduced to *touch* sensations. For example, to take perhaps the simplest illustration, if the hand be slowly advanced towards a fly on a window-pane, the insect, if it be a vigorous specimen, will evade the caress. But if the hand be advanced towards the fly when the insect is on the opposite side of the glass to the hand, it may often be necessary to tap severely in order to disturb its wanderings.

Apart from air currents due to the motion of the hand, and possibly some convection currents due to the heat of the same, it is difficult to afford any other satisfactory explanation of this simple phenomenon, which any one can examine for himself with the greatest of ease.

J. P. O'HEA.

St. Beuno's College, St. Asaph,
March 24.

The Resonance Theory of Hearing.

THE difficulty expressed by Sir James Barrett in NATURE of March 24, p. 396, is probably more apparent than real. If attention is focussed on the relative dimensions of the various parts of the cochlea rather than their actual sizes, I think that the range of analysis can be explained.

In the short compass of a letter I cannot deal with a full consideration of the analytical mechanism of the cochlea. A variation in pressure applied to the *fenestra ovalis*, if it is to cause a movement of the basilar membrane, must cause movement of the liquids in the cochlea. The impedance due to the inertia of the liquid is considered by Mr. Wilkinson as a "load" on the vibrating strings. In all considerations of the action of the cochlea the influence of the viscosity of the liquid has been overlooked (see *Philosophical Magazine*, 1922, vol. 43, p. 349). The friction of the liquid against the walls of the cochlea impedes the movement of the liquid so that if the diameter of the cochlea were uniform the resistance would be proportional to the distance from the *fenestra ovalis*. As the cochlea becomes narrower this is a safe assumption. If the highest audible note acts on the basilar membrane 5 μ from the commencement of the cochlea, the ratio of the impedance due to viscosity of this highest note to the lowest note might be 35,000 to 5. This is approximately the ratio given by Mr. Wilkinson without the assumption of any difference in tension in the fibres of the basilar membrane. I do not wish to imply that there is no difference in tension, but the greater bulk of the spiral ligament may be merely to resist a greater strain, and is not necessarily an indication of a greater initial tension.

If one wishes to look at this subject from the point of view of resonance, the effect of viscosity can be illustrated by narrowing the orifice of an air resonator. This lowers the note, just as the viscosity makes the note lower for the distal end of the cochlea, but the viscosity of a liquid will be much more important than the viscosity of a gas. Viscosity, however, is only one of the factors concerned in sound analysis.

H. E. ROAF.

London Hospital Medical College,
Whitechapel Road, E.1,
March 26.

The Sun-Cult in Ancient Egypt.

By AYLWARD M. BLACKMAN, D.Litt.

I.

THE recent discovery of Tutʿenkhamūn's tomb has naturally aroused a great deal of interest in the attempt made by that king's father-in-law, Ōkhnatōn, to establish a monotheistic form of sun-worship as the State religion of Egypt, and indeed of the whole Egyptian empire. Properly to appreciate this very striking phase of Egyptian religious thought, it is necessary to have some knowledge of the old "orthodox" sun-cult, the State religion of Egypt, since at any rate the sixth, and possibly the third dynasty—a cult which can be traced back to the very dawn of Egyptian history.

The centre of this ancient sun-cult was On, the Heliopolis of the Greek writers, a city which lay close to Memphis and the site of modern Cairo. Heliopolis was almost certainly the political centre of a united Egypt in the predynastic period, though at a time not necessarily long anterior to the beginning of the first dynasty and the founding of Memphis by Menes. The predynastic king of Heliopolis was high-priest of his city-god, the sun-god Rēʿ-Atum, and was also regarded as his embodiment. Immense influence was exercised by Heliopolis upon Egyptian theology and ideas in general, and even when Heliopolis ceased to be the actual capital of Egypt, the Egyptian king was still regarded as the embodiment of the sun-god and his high-priest, and Rēʿ-Atum still maintained his place as the State-god. Owing to the religious and political ascendancy of Heliopolis, a number of the local provincial gods were identified with the sun-god by their priests in order to enhance their prestige. Of course, this identification was particularly likely to take place when what was once a provincial town became the centre of government, as did Heracleopolis at the beginning of the ninth, and Thebes at the beginning of the eleventh dynasty.

As a result of their being identified with the Heliopolitan sun-god, and owing to the great prestige, and, no doubt in early times, superior culture, of Heliopolis, the temples erected for the worship of the solarised local gods were copies of the Heliopolitan sun-temple; moreover the liturgy celebrated therein in honour of these divinities was that celebrated in honour of their Heliopolitan prototype. In course of time the Heliopolitan form of temple was universally adopted in Egypt, and also, by a natural process, the Heliopolitan liturgy came to be celebrated in honour of every important god and goddess throughout the length and breadth of the land. This remarkable uniformity in temple architecture and in worship seems to have prevailed so far back as the old kingdom, about 2900 to 2475 B.C.

The king of Egypt, as we have seen, was the high-priest of the sun-god. He was also high-priest of all the local divinities of Egypt, and in this capacity he celebrated, or rather was supposed to celebrate, the liturgy in every Egyptian temple. His relations with the solarised divinities were of course practically the same as his relations with the Heliopolitan sun-god himself, a circumstance which naturally must have influenced his relations with other divinities and must have helped forward greatly the solarisation of all Egyptian temple-worship.

What, it may be asked, were the ideas of these ancient sun-worshippers as to the nature and character of their god? The most outstanding of all the qualities attributed to the sun-god by the Heliopolitan priests is his righteousness. The sun-god is not only represented as loving righteousness and truth and hating iniquity, but also it was said that he it was who "fashioned righteousness." Righteousness is so much a part of the god's being that he is said to live (*i.e.* feed) on it, just as Hapi the Nile-god is said to live on fish! This righteous god demanded righteousness in his worshippers also, and before the Osirianisation of the Egyptian conceptions of the life after death, a process which they underwent in the period between the end of the Old and the beginning of the Middle Kingdom (about 2475 to 2160 B.C.), the sun-god was regarded as the judge of the dead, in which capacity certain texts represent him as weighing righteousness in a balance, *i.e.* testing the righteousness of the dead.

Now the king of Egypt (in the first instance the king of Heliopolis) was thought to be, as we have seen, the embodiment of the sun-god. Accordingly, like his divine prototype he was supposed to be the upholder of righteousness, truth, and justice. But the close association of the king with the god not only associated the god's righteousness with the king: it also associated the kingship with the god. Thus the sun-god, who is represented in the myths as the first king of Egypt, came to be regarded as the prototype of all Egyptian sovereigns, the ideally righteous king, the pattern of all would-be righteous Pharaohs. In a literary composition of the Feudal Age, describing the miserable plight of Egypt under the rule of a weak Pharaoh, a sage contrasts the prevailing unhappy conditions with the state of affairs in that far-off golden age when the sun-god, the ideal king, ruled over Egypt. He speaks of the sun-god as "the shepherd (lit. herdsman) of all men, with no evil in his heart." "Where is he to-day?" he asks. "Does he sleep perchance? Behold his might is not seen!"

Purity, and particularly physical purity, was another attribute of the sun-god. Everything connected with him must, it was maintained, be pure, and only those who were pure could approach him. Consequently lustral washing was a marked feature of the sun-cult, no priest being able to enter the sun-temple (eventually any temple) to officiate until he had undergone purification. Even the sun-god himself is represented as washing or being washed every morning in some mythological lake or pool before appearing above the eastern horizon.

Now according to one conception, the sun-god was reborn every morning, having been born in the first instance, be it noted, out of the waters of the celestial ocean. Naturally enough, therefore, his daily rebirth came to be associated with his daily lustration, and he was supposed to be reborn every day at dawn as the result of washing or being washed in the waters of this or that sacred pool. In accordance with this conception, an early and important episode in the liturgy, which was celebrated every day at dawn in all Egyptian temples (in the first instance, of course, the Heliopolitan sun-temple), was the washing or sprinkling of the divinity's (originally the sun-god's) cultus-image with water, in imitation of the sun-god's supposed daily matutinal lustration.

The Heliopolitan king, the sun-god's embodiment, was, as already stated, his high-priest, and in this capacity he entered, or was supposed to enter, the sun-temple every day at dawn to celebrate the liturgy. Before he entered the god's presence he had, like every other priest, to undergo purification, but in his capacity of embodiment of the sun-god he was conceived of as reborn as the result of his ceremonial washing, just as was his divine prototype. As we shall see, the king was also regarded as the son of the sun-god, and was thus thought of as rebegotten as well as reborn through the agency of the lustral water, this being identified with the sun-god's own efflux, the very efflux with which he had brought into being his two children, Shu and Tefēnet. The king's lustral washing took place in an adjunct of the sun-temple, called the House of the Morning, so named on account of the very early hour at which this ceremony took place. The king not only underwent lustration in this chamber, but he was also robed, anointed, and crowned there, invested with the royal insignia, and apparently also presented with a light repast, after which proceedings he was ready to enter the temple to officiate.

The consort assigned to the Heliopolitan sun-god by his priests was Ḥatḥor, a goddess who was especially associated with music and dancing. The queen, as wife of the high-priest of the sun-god, was, in accordance with Egyptian custom, that god's high-priestess; moreover as wife of the embodiment of the sun-god she was considered to be the god's earthly wife, and so was identified with Ḥatḥor. Like her divine prototype she was associated with music, and it was her function to sing and rattle her sistrum while her husband, the high-priest, celebrated the liturgy.

A notable feature of the worship of Ḥatḥor was the performances of her musician priestesses, who were attached to her temple in large numbers. These performances consisted in dancing to the accompaniment of the rattling of sistra and the beating of single-membrane drums. Since Ḥatḥor was assigned to the sun-god as his wife, musician-priestesses were attached to his temple, and their dancing, singing, and playing thus became a feature of the sun-cult—eventually of all the solarised cults of Egypt. Over these musician-priestesses in the provincial temples presided the high-priestess, the wife of the high-priest, who, as inscriptions occurring in several temples explicitly state, was regarded as the wife of the god, and was as such identified with Ḥatḥor—the god himself being identified with the sun-god. The musician-priestesses attached to the great solar or solarised temple at the capital were, of course, presided over by the queen, the earthly counterpart of Ḥatḥor *par excellence*. These musician-priestesses of Ḥatḥor consciously impersonated Ḥatḥor in their performances, and are actually spoken of as Ḥatḥors. Thus not only the high-priestess was identified with Ḥatḥor, but the musician-priestesses over whom she presided were designated Ḥatḥors also.

Since the chief musician-priestess—at the capital the queen, or in the provinces the local high-priest's wife—was regarded as the god's earthly consort, the ordinary musician-priestesses were reckoned to be his concubines, in which connexion it is interesting to note that the Temple of Luxor, which was dedicated to the solarised Theban Amūn, was known as the Southern Ḥarīm of Amūn; so it was possibly the headquarters of that god's concubines.

Owing to the queen holding the position of wife of the sun-god, her son, the future king, naturally came to be regarded as the actual physical son of that divinity, the explanation of this wondrous happening being that the god had intercourse with the queen by incorporating himself in the reigning Pharaoh.

A brief description must now be given of an ordinary Egyptian temple, and some account of the ideas which the Egyptians entertained with regard to it, all of which will show effectually how preponderating was the influence of Heliopolis in all matters religious, and how complete was the process of solarisation which Egyptian temple-worship and all its accessories had undergone, certainly before the end of the Old Kingdom, possibly at a much earlier date.

A great ornamental gateway flanked by two towers, commonly called a pylon, admitted to an open court surrounded by a colonnade. Behind this court was the hypostyle or pillared hall, and behind it again, buried in profoundest darkness, lay the sanctuary, containing the cultus-image of the divinity to whom the temple was dedicated. In adjoining rooms were enshrined the images of the co-templar divinities. Yet other rooms served as store-chambers for the sacred utensils and vestments, or for the performance of special ceremonies.

Owing to the prevailing solar influence, Egyptian temples, certainly in early times and often later, were orientated east and west, so that the rising sun at the equinoxes might light up their dark interiors. Indeed, according to the current Egyptian conception, it was the sun-god before all others who dwelt in every temple, which was regarded as a small replica of heaven itself. Thus a favourite description of a temple is that it is "like heaven in its interior, while Rēʿ (the sun-god) rises within it."

Against the eastern face of either of the above-mentioned pylon-towers were erected two or four, sometimes even five, tall masts—four to ten in all—from the tops of which fluttered white, green, blue, and red flags. These towers themselves were equated with the two sisters Isis and Nephthys, who were regarded as a pair of midwives lifting up the newly-born sun into the sky every morning.

In front of the pylon there generally stood two obelisks, one on either side of the gateway. The obelisk, or rather the pyramidion on top, was closely connected with the sun-cult, being a replica of the sacred *benben*-stone in the temple at Heliopolis. This stone was the emblem of the sun-god, one of the forms under which he was worshipped, and on it he was said to have sat when he begat of himself the god Shu and the goddess Tefēnet.

Colossal statues of the royal founder or benefactor of the temple were often erected in front of the pylon beside the obelisks. Other statues of the king, representing him either in the guise of a worshipper or offerer, or as just standing or seated, were set up in various parts of the temple. Through the medium of these statues, which to the Egyptian mind were very closely connected with the person they represented (that person being regarded as immanent in them), the king could, according to the character of the statue, function perpetually either as worshipper or offerer, or else as the recipient of worship and offerings.

In the main sanctuary, and in the sanctuary of each of the co-templar divinities, was a shrine containing the cultus-image, which was as a rule quite small—sixteen inches to four feet in height—and made of wood. Sometimes the shrine was a monolithic naos set up against the back wall of the sanctuary, with a bronze frame inserted in front fitted with double doors. More often the shrine was in the form of a boat, which rested upon an altar-like stone pedestal, the place where it stood being designated "the great place." In the centre of the boat, covered with a veil, was a cabin containing the image. Poles were attached to these boats so that they might be carried in procession, the number of priests who supported them varying from eight to twenty-four, or even twenty-six. In the sanctuary of the Heliopolitan sun-temple there were two such boat-shrines, representing the morning- and evening-barque of the sun-god. The boat-shrine is undoubtedly of solar origin, for it was the sun-god in particular who was conceived of as sailing across the sky in a boat.

The sanctuary, or else the actual naos containing the image, is often designated "Heaven" or the "Horizon" in inscriptions, and one of the titles borne by the high-priest of the solarised Theban Amūn was "Opener of the Doors of Heaven in Elect-of-Places (Luxor)," it being the duty of the chief officiating priest to open the doors of the shrine or sanctuary at an early stage of the temple liturgy.

Every temple possessed its sacred pool containing the water used for purificatory purposes, and it is to be noted that this pool, for reasons that have been fully set forth above, seems always to have been associated with the sun-god.

Again, every temple down to the latest times possessed its vestry or House of the Morning, an adjunct, as has already been pointed out, of the ancient Heliopolitan sun-temple.

One of the clearest proofs of the complete solarisation of institutional religion in Egypt is to be found in the organisation of the priesthood, which at every temple was divided into four "watches," or, as the classical writers designated them, phylæ. These "watches" bear the names of the four quarters of a ship—the bow-, stern-, starboard-, and larboard-watch, names which mythological texts assign to the four watches into which the crew of the sun-god's ship was divided. It was evidently the Heliopolitan priests who were first divided into four watches bearing these names, for, as already stated, the sun-god was supposed to traverse the heavens in a ship and his priests may well have been regarded as his crew.

The liturgy itself consisted largely of a series of toilet-episodes, and thus closely resembled the ceremonial toilet of the Pharaoh in the House of the Morning, a resemblance due to the fact that both imitated the same performance, the supposed daily matutinal ablutions of the sun-god, the cultus-image of the divinity (originally the sun-god) being washed or sprinkled with water every day at dawn, as the god himself was believed to be. That the other toilet episodes in the temple liturgy—robing, anointing, crowning, etc.—were like those performed for the king, was due to the fact that the sun-god, for whom the rite was instituted, was himself regarded as a king—the divine prototype of all Heliopolitan kings. The chief officiant at the liturgy was supposed to be the Pharaoh, but it was of course impossible for the supreme head of the highly organised Egyptian state of historic times to function daily as high-priest, even in the temple at the capital, let alone in the countless temples scattered over the length and breadth of the land. His place was therefore taken by a deputy, the local high-priest, or some other member of the higher grade of the priesthood. In addition to the chief officiant a number of assistant priests took part in all the ceremonies, as certain representations clearly show.

The liturgy falls into three main divisions: (1) A series of pre-toilet episodes, among which were included the unbolting and opening of the sanctuary or naos doors, the sweeping of the sanctuary floor with a cloth or besom, preliminary fumigations with incense, the prostration of the celebrant, the chanting of the praises of the god, and the removal of the image from the shrine. (2) The lustral washing of the image, followed by a long series of other toilet performances. (3) The liturgy terminated with the presentation of a meal to the god, a lengthy and highly ceremonious proceeding. When the food- and drink-offerings had all been laid in order before the image—the heaped-up food offerings surmounted with bouquets of flowers and the wine-jars wreathed with garlands—the officiant extended his right arm and, bending his hand upwards in the prescribed manner, pronounced a formula beginning with the words "An offering which the king gives." The recitation of this formula was preceded by the burning of incense and the pouring out of a libation. The priest having next recited the formula of "Summoning the divinity to his repast," performed the act of consecration, by which each item of food and drink was finally made over to the divine banqueter. This act consisted in the king, or his deputy the priest, standing before what was to be offered, and four times stretching out over it or towards it a ceremonial baton called the *kherp*-baton, which he grasped in his right hand.

The last act of the officiant before he left the sanctuary was to remove all traces of his own and his assistants' footprints. This he did by sweeping the floor once more with a cloth or besom. The sanctuary door was then closed and bolted and a clay seal affixed to the bolts.

Before bringing this preliminary article to an end, it should be pointed out that music, vocal and instrumental, was a great feature of Egyptian worship—a much greater feature than may have appeared from what has already been said in connexion with the musician-priestesses. These priestesses, it would seem, headed by the god's earthly wife, the high-priestess, rattled their sistra, beat single-membrane drums, and chanted hymns in the divinity's praise, all the time that the chief officiant and his assistant priests were executing the various ritual acts, while male musicians also bore their part in the proceedings, singing, and playing on flutes and stringed instruments.

The following and concluding article will deal with the monotheistic Aton-religion instituted by Ōkhnatōn, and so enthusiastically practised and propagated by him at his capital, El-Amarna, in Middle Egypt.

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The Photosynthesis of Plant Products.[1]

By Prof. I. M. Heilbron.

Despite the enormous strides that have been made by chemists during the last decades in the elucidation of many classes of plant products and the actual synthesis of individual members, the methods hitherto employed in the laboratory are so essentially different from those carried out by the plant that the synthetic processes of the living organism have come almost to be regarded as something fundamentally apart from those of the laboratory. The investigations on photosynthesis now being carried out in Liverpool by Prof. Baly and myself, although as yet of a quite preliminary nature, have, in my opinion, already shown that such a conclusion is entirely unwarranted and that the key to the problem of plant syntheses is to be found in the study of the energy transformations involved in the primary reaction wherein the plant brings about the fixation of atmospheric carbon dioxide. Apart from the purely academic interest of the subject, the problem of photosynthesis demands the attention of the community as a whole, for, with the elucidation of the reactions involved, the economic aspect of the question must inevitably become more prominent, and practical results of the greatest value to mankind may conceivably accrue.

The work of the earlier investigators on the subject has led to the formulation of certain definite conclusions. Thus, it has been proved beyond question that photosynthesis takes place in the green leaf of the plant and that, under natural conditions, assimilation apparently consists in the absorption of carbon dioxide by means of the chlorophyll contained in the chloroplasts and its deoxidation and condensation therein, in the presence of water and sunlight, to sugars. It is obvious that, in order to obtain any satisfactory explanation of the rôle played by the chlorophyll, its constitution, and above all its reactions, must be known. The first advance in this direction is due to von Baeyer,[2] who suggested that the initial product of assimilation was formaldehyde, which then further condensed to form carbohydrates. This hypothesis was rapidly put to the test in two directions. Innumerable attempts have been made to prove the presence of formaldehyde in the green leaf itself, but in every case where this appeared to be established its formation could as readily be explained as being derived from sources other than assimilation. As regards the production of formaldehyde from carbon dioxide *in vitro*, this has actually been carried out in numerous ways,[3] none of which, however, are directly comparable with the conditions existing in the plant itself. The most detailed work in this connexion is that of Moore and Webster,[4] who showed that, under the action of light, formaldehyde was readily produced in solutions of carbonic acid containing colloidal uranium hydroxide or ferric hydroxide. As a result of these experiments, Moore concluded that, although chlorophyll had come to be universally regarded as the fundamental agent for photosynthesis, the evidence was purely inferential, and it was more probable that the synthesis of formaldehyde in the presence of sunlight was actually due to the inorganic iron present in the colourless portion of the chloroplast.

Recent research shows this hypothesis to be incorrect. Iron is undoubtedly essential to plant life, just as it is to animal life, and its function seems to be closely associated with chlorophyll formation. Leaves starved of iron suffer from chlorosis but, in these, photosynthesis does not take place, and there can be little doubt that the real catalyst for the assimilation reaction is chlorophyll. Our knowledge of the constitution of this interesting and highly complex pigment is mainly due to the work of Willstätter and his collaborators,[5] who have established the fact that the following four pigments are invariably present in the green leaves of all land plants: Chlorophyll A, $C_{55}H_{72}O_5N_4Mg$, chlorophyll B, $C_{55}H_{70}O_6N_4Mg$, carotin, $C_{40}H_{56}$, and xanthophyll, $C_{40}H_{56}O_2$. From an exhaustive study of the assimilation of carbon dioxide by the green leaf, Willstätter[6] has been able to arrive at certain very important generalisations. He has found that in all cases the oxygen evolved is absolutely equivalent to the carbon dioxide absorbed, which definitely proves that formaldehyde must be the first product, since the primary formation of such other substances as have from time to time been suggested would necessitate a volume ratio greater than 1 : 1. Further, from the results of experiments carried out both in the leaf and *in vitro*, he has been able to show that, although chlorophyll is inactive to dry carbon dioxide, it is nevertheless capable of combining with carbonic acid to form a labile addition compound. He concludes that this latter, by the absorption of light energy, is rearranged into a formaldehyde peroxide complex from which, by means of enzyme action, formaldehyde is liberated, oxygen evolved, and chlorophyll regenerated.

[1] Substance of lectures delivered at the Royal Institution on February 1 and 8.

[2] Ber. (1870) 3, 68.

[3] Usher and Priestley, Proc. Roy. Soc. (1906) B, 77, 369.

[4] Proc. Roy. Soc. (1913) B, 87, 163.

[5] Willstätter und Stoll, "Untersuchungen über Chlorophyll," Berlin, 1913.

[6] Willstätter und Stoll, "Untersuchungen über die Assimilation der Kohlensäure," Berlin, 1919.

This work still leaves much unexplained and in no way helps to disentangle the paradox that whereas, on one hand, formaldehyde must actually be produced, it nevertheless does not exist in the leaf. Nor does it afford an explanation of the rapid synthesis of either the disaccharides, such as cane-sugar, or of storage starch. Again, it is curious that, if the reactions are actually those specified by Willstätter, Nature should, apparently by caprice, invariably ensure the presence of the two chlorophyll components and also the carotinoid pigments, when one chlorophyll individual would by itself be sufficient. It would seem more probable that the four pigments are present because each has an absolutely definite rôle to play in the mechanism of assimilation. This suggestion is strongly supported by a consideration of the striking oxygen values existing between the two pigment classes, these being in strict agreement with the amount of oxygen liberated in the photosynthetic operation.

Returning now to the consideration of the primary synthesis wherein carbonic acid is deoxidised to formaldehyde, this reaction is a highly endothermic one, impossible to realise under the conditions commonly employed in the laboratory. On the other hand, carbonic acid is able to absorb light of very short wave-length ($\lambda = 200\ \mu\mu$), and, if exposed to light of this frequency, the formation of formaldehyde, without the agency of any catalyst, can readily be demonstrated under these purely photochemical conditions. Moreover, in the presence of a suitable basic coloured substance, such as malachite green, with which the carbonic acid can combine loosely, the formation of formaldehyde can be demonstrated in visible light, the malachite green acting as a photocatalyst for the reaction.[7]

Carbohydrate Production.

The formation of sugars on exposure of aqueous solutions of formaldehyde to ultra-violet light was demonstrated by Moore and Webster.[8] These observations have been fully confirmed, and it has been found that the wave-length of light which brings about this reaction ($\lambda = 290\ \mu\mu$) is photochemically distinct from that required for the synthesis of formaldehyde itself. In our earlier experiments in Liverpool, it was considered that the photosynthetic formation of carbohydrates had to take place in two distinct stages, but, as will be explained below, later experiments have shown that this interpretation was incorrect, the actual process being simpler. The formaldehyde molecule, when first produced by photosynthesis from carbon dioxide, exists in a highly reactive phase, identical with that obtained when ordinary formaldehyde is photochemically activated. This type of formaldehyde we have designated "activated formaldehyde," and it is this which must be photocatalytically produced through the agency of the chlorophyll, and immediately condenses to sugars, for, as is well known, ordinary formaldehyde has no such property. It follows from this that the formaldehyde detected in the carbonic acid experiments cannot have been a direct product of photosynthesis, but must have resulted from a subsequent decomposition of photosynthesised sugar. That carbohydrates readily yield formaldehyde under the influence of short wave-length light has been proved experimentally, and thus the detection of formaldehyde in any photochemical operation may be regarded as sure evidence of photosynthesis.

The investigation into the nature of the sugars formed by the photochemical activation of formaldehyde is still being carried out, but we have been able to prove conclusively that the condensation leads to the production of hexose sugars alone. This fact affords a ready explanation of the formation of disaccharides and starches, for the freshly photosynthesised hexose molecule must exist in a highly reactive phase, and consequently further condensations will inevitably take place.

Nitrogen Assimilation.

The problem as to the origin of the many classes of nitrogen compounds occurring in the vegetable kingdom is one fully equal in importance to that of the formation of carbohydrates, but although many have speculated on their possible synthesis, little definite evidence has hitherto been adduced to account for their production. The questions which have to be considered in this connexion are, first, under what conditions and in what state does the nitrogen enter the plant, and secondly, is the fixation process a photosynthetic reaction? With regard to the manner in which nitrogen is supplied, the general method would appear to be that it passes into the roots in the form of nitrates, or possibly ammonium salts, present in the soil. In addition to the introduction of nitrogen in this manner, Moore[9] has found that in the case of unicellular algæ, providing abundant carbon dioxide is present, elemental nitrogen from the atmosphere can be absorbed and directly utilised. This discovery, which is of quite exceptional interest and fully corroborates Jamieson's[10] earlier investigations, is still further supported by the recent observation of Lipman and Taylor,[11] who claim to have proved that ordinary wheat is able to assimilate up to 20 per cent. of its total nitrogen content in the form of free nitrogen.

It was noted by Schimper that nitrites are invariably present in the green leaf when kept in the dark, but that they rapidly disappear on exposure to light, and the deduction may thus be drawn that these are the active substances employed in the nitrogen fixation. The direct assimilation of atmospheric nitrogen in no way invalidates this conclusion, for there can be little doubt that the free nitrogen will readily react with the nascent oxygen formed during the photolysis of the carbon dioxide to yield oxides of nitrogen.

With these facts in mind, exhaustive experiments are now being carried out in Liverpool on the interaction of nitrates with activated formaldehyde. It has been found that under all conditions the primary reaction product is formhydroxamic acid,[12] $\begin{matrix} H \\ HO \end{matrix}\!\!>\!C{=}NOH$, a substance which had previously been obtained by Baudisch[13] in his pioneer work in this field. The formation of formhydroxamic acid takes place only in the presence of activated formaldehyde, no trace of it being found

[7] Baly, Heilbron, and Barker, Jour. Chem. Soc. (1921) 119, 1025.
[8] Proc. Roy. Soc. (1918) B, 90, 168.
[9] Moore and Webster, Proc. Roy. Soc. (1920) B, 91, 201; (1921) B, 92, 51.
[10] Reports Agricultural Research Association, Aberdeen (1905–1911).
[11] *Science*, 1922, November 24.
[12] Baly, Heilbron, and Hudson, Jour. Chem. Soc. (1922) 121, 1078.
[13] Ber. (1911) 44, 1009.

when solutions of ordinary formaldehyde and potassium nitrate are allowed to remain in the dark. Now, as this acid is also produced on passing carbon dioxide through aqueous solutions of either potassium nitrate or potassium nitrite exposed to ultra-violet light, the requisite proof is furnished of the statement that the freshly synthesised formaldehyde must be beyond doubt activated formaldehyde. These experiments have led us to the conclusion that formhydroxamic acid marks the initial stage in the phytosynthesis of nitrogen compounds. This view is further substantiated by the fact that, on exposure to ultra-violet light, formhydroxamic acid rapidly reacts with activated formaldehyde to form various other products, many of a complex nature, whereas in the absence of light no such change occurs.

In the course of these experiments, other facts of great importance have been noted. It has been found that by employing excess of nitrite no reducing sugars whatsoever are formed, but that if the activated formaldehyde is in excess of that utilised by the nitrite, the presence of reducing sugars can be readily detected. These experiments prove that the synthesis of nitrogen compounds by the interaction of nitrites with activated formaldehyde takes precedence over the condensation of the latter to carbohydrates. In the plant, however, as the amount of nitrogen actually fixed is small in comparison with the total carbon assimilated, both carbohydrate and protein formation take place simultaneously.

As regards the type of substances which have been classified up to the present, conclusive proof of the formation of α-amino acids has been obtained, and thus a definite intermediate stage in protein production has been reached. At least four distinct types of α-amino acids have so far been isolated in the form of their copper salts, and it is certain that at least one of these is a complex acid, possibly analogous to histidine.

In addition to the synthesis of amino acids, nitrogen bases, such as methylamine, pyridine and piperidine, have been isolated. Substances of alkaloidal character are also formed in the reaction, but as yet we have been unable to separate any one alkaloid in sufficient quantity for detailed investigation.

Another line of attack, at present in active progress, is the study of the action of ammonia on photochemically activated formaldehyde. Here again it has been ascertained that, whether one starts from carbon dioxide and ammonia or from ordinary formaldehyde and ammonia, identical products are obtained. Moreover, although under normal conditions interaction only occurs under the influence of light of very short wavelength, by employing ammoniacal copper solutions the reaction can be photocatalysed to take place in visible light. In all cases the presence of methylamine, pyridine or piperidine, can again be recognised after comparatively short exposure to light, and by extending the period of illumination to several days the presence of alkaloids can also be experimentally confirmed.

In this case it has been possible to isolate an individual alkaloid in sufficient quantity to enable numerous qualitative and physiological tests to be carried out. Despite the difficulties of identification of these substances, the experimental evidence obtained would seem definitely to indicate that this photosynthetic alkaloid is coniine.[14]

In conclusion, I would direct attention to some general deductions naturally arising from the work in hand. According to the views now put forward, it necessarily follows that, both in the case of the photosynthesis of carbohydrates and also in that of the phytosynthesis of nitrogen products, the whole centre of activity must be contained in the green leaf itself. As to the manner in which translocation from this point to other portions of the plant is brought about, it may be suggested that, as the synthesis of active hexoses takes place concurrently with the production of nitrogen compounds, the conditions are especially favourable for glucoside formation. In this way a method would be found for the easy removal of insoluble materials from the leaf.

Finally, I would emphasise the point that in regard to the work being carried out by Prof. Baly and myself, our only claim is that we consider it by no means impossible to reproduce in the laboratory processes strictly analogous and directly comparable with those taking place in the plant. The chemistry of photosynthesis is new and strange, and as such will undoubtedly be viewed with a certain degree of scepticism, for the inherent conservative spirit among even scientific investigators tends to react against any new order of things. Photosynthesis is in the main the chemistry of one single substance—formaldehyde. The whole process is dependent on energy supplied from the sun and made available through the wonderful activity of the pigment chlorophyll.

[14] Baly, Heilbron, and Stern, Jour. Chem. Soc. (1923) 123, 185.

Obituary.

Lord Carnarvon.

We much regret to record that Lord Carnarvon died at Cairo on April 5, from the effects of pneumonia, supervening on erysipelas and blood-poisoning, the result of a bite on the cheek by an insect, presumably a mosquito.

Lord Carnarvon was born on June 26, 1866, and was the son of the fourth Earl, whom he succeeded in 1890. He was educated at Eton and Trinity, Cambridge. He travelled extensively, won a reputation as a big-game shot, and was interested in the Turf. He was a great connoisseur and collector of illuminated books, manuscripts, and medals, as well as of antiquities of fine workmanship and small size. Of the last-named he had a remarkable and, in some respects, a unique collection. It is, however, in connexion with the study of the history and antiquities of Egypt that Lord Carnarvon's name will be handed down to posterity. In 1906 he, in association with Mr. Howard Carter, formerly inspector under the Egyptian Antiquities Department, began excavations, chiefly on the north side of the Assassif Valley near Der el Bahari, which resulted in the discovery, among other finds, of the tomb of the " King's Son " of Dynasty XVIII. in 1908 and, in 1910, of a rich tomb of Dynasty XII. The results of these early excavations were embodied in Lord Carnarvon's "Five Years' Excavations in Thebes," which appeared in 1912.

After the War, Lord Carnarvon began excavations in the Valley of the Kings, a site which had rewarded the excavations of Mr. Theodore M. Davies with some remarkable finds. No striking results were obtained until November 5 last, when Mr. Carter discovered the tomb of King Tutankhamen—a discovery unique in the annals of archæology. The interest of the objects taken from the tomb, remarkable both in their number and character, grew from day to day, and culminated on February 17, when the opening of the inner chamber revealed the shrines in which it is expected that the body of the king will be found. Work was then closed for the season.

It adds a note of tragedy to Lord Carnarvon's death that he will not be present when the opening of the innermost shrine crowns his labours, but his name will always be honoured as one who added a vast store to our knowledge of the civilisation of Ancient Egypt.

DR. C. I. FORSYTH MAJOR, F.R.S.

DR. CHARLES IMMANUEL FORSYTH MAJOR, who died at Munich on March 25, aged seventy-nine, was born in Glasgow, of Scottish parents, but removed when an infant to Constantinople, and lived for most of his life abroad. He was educated in Switzerland, Germany, and Italy. Graduated Doctor of Medicine in Basle in 1868, and began his career as a medical practitioner in Florence.

Dr. Major was, however, always interested in natural history, and his association with Rütimeyer in Basle led him to become an enthusiastic student of fossil mammals. While occupied with his professional duties in Florence, he took every opportunity of collecting and examining the mammalian remains found in the superficial deposits in the valley of the Arno, and from 1872 onwards he published in Italy a series of small papers on these remains, describing and discussing them in a more exhaustive manner than had previously been attempted. He summarised his results in the Quarterly Journal of the Geological Society of London in 1884, pointing out that the later Pliocene mammals were all distinguishable from those of the early Pleistocene when fossils were studied in detail. At the same time he published valuable memoirs on the dentition of rodents from the Bohnerz of Switzerland and South Germany (*Palæontographica*, xxii., 1873), and on the dentition of the early true horses (*Abhandl. Schweiz. Paläont. Ges.*, 1877–80).

About 1886 Dr. Major abandoned his medical practice, and began to devote himself entirely to scientific research. With the help and encouragement of his Swiss friend, M. W. Barbey, he made a thorough exploration of the Pliocene accumulation of mammalian bones in the island of Samos, and brought back a great collection, of which part was presented by M. Barbey to the Collège Gaillard at Lausanne, and the other part was purchased by the British Museum. In 1889 Dr. Major made another important collection of mammalian remains from a Pliocene torrent-deposit at Olivola in the Carrara mountains in Italy, and this was also purchased by the British Museum. Dr. Major followed his collections to the British Museum, and was temporarily employed there in cataloguing the fossil mammals until 1909. While thus occupied he published a valuable series of papers in London. He also arranged to prepare a Catalogue of Fossil Rodentia for the British Museum, and a large monograph of the Samos Mammalia, which unfortunately were never produced.

In 1893 Dr. Major contributed his important memoir on the skull of a giant lemur, Megaladapis, from a cavern in Madagascar, to the Philosophical Transactions of the Royal Society, and the novelty of this discovery led him to plan an exploration of the caverns and marshes of Madagascar. With the aid of a government grant from the Royal Society, he visited Madagascar in 1894–95, and brought back an important collection of fossil mammals and birds, which is also now in the British Museum. On these fossils he wrote several descriptive papers.

In his later years, however, Dr. Major found increasing difficulty and diffidence in preparing his results for publication, although his researches were pursued with accustomed diligence. Much of his valuable work on rodents and on the relationship between the fossil Samotherium, which he discovered in Samos, and the existing okapi of the Congo Forest, is thus unfortunately lost to science. Dr. Major was elected a fellow of the Royal Society in 1908, and about the same time was awarded a small Civil List pension. He then returned to the Mediterranean region which had interested him for so many years, and spent most of the remainder of his life in Corsica. He still continued to collect and study mammalian remains, chiefly from the caverns and rock-fissures of Corsica, but he now ceased to do more than make manuscript notes.

A. S. W.

MR. E. W. VREDENBURG.

GEOLOGY has lost a cultured worker by the death of Ernest Watson Vredenburg, who passed away on March 12, at the age of fifty-three. His death was probably hastened by the constant and now painfully verified foreboding that he might never be able to finish the great task which he had undertaken of revising the Tertiary palæontology of the Indian region. We have had occasion at times to notice some of the numerous instalments which he has published during the past few years in the Records of the Geological Survey of India; they and other papers now in the press were intended to prepare the way for a comprehensive monograph which he hoped would justify his reason for differing from his colleagues on some questions of stratigraphical correlation; but the burden was too great for that hyper-sensitive, artistic, and retiring nature which tended to keep him apart from his colleagues, who nevertheless appreciated his deep learning, unrelenting industry, and tenacious adherence to independent views.

Mr. Vredenburg, who was half French in race and wholly so in upbringing, graduated at Paris in Science and Letters before entering the Royal College of Science and School of Mines, where he took a double associateship, in geology and mining, before joining the Geological Survey of India in 1895. He spent the first part of his official work on the relatively uninteresting unfossiliferous rocks of Central India, and did not get an opportunity of discovering his main bent till his transfer to Baluchistan, the geological features of which he revised and summarised in 1910. There and in the adjoining regions of Sind he became deeply interested in the stratigraphy and palæontology of the

Lower Tertiary system, extending his work afterwards to the younger beds in the Burma oil-fields.

South Kensington students will remember him as a brilliant pianist who would have had a distinguished position in the musical world if he had not concentrated on the palæontology of India. During his early days in India he showed a tendency to become engrossed in archæological interests until palæontology claimed him first as a devotee and finally as a victim.

Count Fernand de Montessus de Ballore.

The small band of seismologists has suffered a serious loss through the death of M. de Montessus de Ballore. Born in 1851, he was trained at the École Polytechnique, where he was a fellow-student of Marshal Foch. In 1881 he was sent as chief of a military mission to San Salvador. There he became interested in the frequent earthquakes of the Central American republics, and he continued his seismological studies on his return to Paris as Directeur des Études at the École Polytechnique. In 1907 he was appointed director of the earthquake-service in Chile, a service which, through his efforts, became one of the first rank.

De Montessus will be chiefly remembered and valued for his studies on the distribution of earthquakes. His great work on " Géographie Séismologique," which occupied his leisure for twenty-four years, was published in 1906. Few men could be so well qualified as he for an undertaking so vast, for he had a good knowledge of six foreign languages. Having collected records of nearly 160,000 earthquakes, he showed that seismic regions follow the principal lines of relief, that, in a group of unstable regions, the most unstable are those of the greatest relief, and that more than 90 per cent. of the earthquakes occurred along two narrow zones occupying great circles of the earth, which he called the Mediterranean circle and the circum-Pacific circle. In 1907 his second work, " La Science Séismologique," appeared and at once took its place as an authoritative treatise.

Besides these two volumes and a small popular book published in 1911, de Montessus was the author of many memoirs. One of the latest was a bibliography of seismology containing the titles of more than 9000 books and papers. In the preparation of these works, he had collected a library, perhaps the most extensive of the kind in existence. This was bought a few years ago by the late President J. C. Branner, and was presented by him to the University of California. C. D.

Prof. M. Abraham.

The issue of the *Physikalische Zeitschrift* for February 1 contains an obituary notice of Prof. Max Abraham by Profs. M. Born and M. v. Laue. He was born at Danzig in 1875 and studied under Planck at Berlin. After graduating he became Planck's assistant, and in 1900 privatdozent at Göttingen. For a short time in 1905 he acted as professor at the University of Illinois, and, after his return to Göttingen, was in 1909 appointed professor of theoretical physics at Milan. The War ended this, and he held temporary posts till last year, when he was appointed professor of theoretical mechanics at Aix-la-Chapelle. Illness prevented him commencing duties there, and he died of tumour on the brain on November 16, 1922. He was well known in this country for his book " Theorie der Elektrizität," for his articles on vectors and on electromagnetic waves in the " Mathematische Encyklopädie," and for his papers on the dynamics of electrons, all giving evidence of a clear and logical mind.

We regret to learn from Australia of the death, at the end of January, of Dr. J. L. Glasson, at the age of thirty-four years. Dr. Glasson was a student of the University of Adelaide, where he worked under Sir William Bragg, and from that University he received his doctor's degree. He succeeded in winning a travelling research scholarship of the Exhibition of 1851, and with it came to this country. He entered Gonville and Caius College, Cambridge, in 1909 as an advanced student, and, going to the Cavendish Laboratory, did valuable research work under Sir J. J. Thomson. In 1912 he was appointed lecturer in physics in the University of Tasmania, Hobart, and while there he did valuable work for the Electrolytic Zinc Co. and for the Tasmanian Carbide Co. This post he resigned in 1919, returning to Cambridge for research for a couple of years, after which he accepted an appointment as lecturer in physics in the University of Melbourne, which he held at the time of his death.

The sudden death from angina pectoris on March 15 of Mr. G. E. Bullen, Curator of the Herts County Museum at St. Albans, is announced. Among the smaller museums in the country there can be few which have been raised to such a pitch of excellence, and this has been due entirely to the whole-hearted devotion and enthusiasm of Mr. Bullen during the past twenty years. A considerable extension and rearrangement of the collections has recently been completed, and, especially on the archæological side, the museum is now a model of what a local museum should be, the clear demonstrative labelling of the exhibits being a special feature. Mr. Bullen's work had been for some time carried on in defiance of indifferent health, and his death at the early age of forty is a great loss.

The *Chemiker Zeitung* of March 17 announces the death in the beginning of March of Prof. Robert Scheibe, formerly professor in the Academy of Mines, Berlin, and later active in South-west Africa and Bolivia. In the issue of March 15 the death on March 10 of Prof. Ernst Salkowski, since 1880 director of the chemical side of the Berlin Pathological Institute, is announced. Prof. Salkowski was born on October 11, 1844, in Königsberg, and at first worked with Virchow. His researches covered a wide field in physiological chemistry.

We regret to announce the following deaths :

Dr. H. H. Stoek, professor of mining engineering in the University of Illinois since 1909, on March 1, aged fifty-seven.

Dr. John Venn, F.R.S., president of Gonville and Caius College, Cambridge, and for many years lecturer in logic and moral philosophy in the University, on April 4, aged eighty-eight.

Mr. S. H. Wells, director-general of the Egyptian Department of Technical, Industrial, and Commercial Education since 1907, on March 28, aged fifty-seven.

Current Topics and Events.

WITH this issue appears the first of a series of supplements which it is proposed to publish from time to time dealing descriptively with subjects of wide scientific interest. The present supplement is devoted to a discourse delivered at the Royal Institution on March 2 by Dr. G. C. Simpson, director of the Meteorological Office, and it provides in a convenient form a synopsis of existing knowledge of common meteorological phenomena. The method of dealing with the subject is characteristic of the present-day physicist, and it is essentially interesting. Saturation and relative humidities are somewhat fully described, and this is followed by a discussion of condensation at temperatures above the freezing point. It is of interest to note that the number of nuclei present in the air varies from a minimum of about 100 per c.c. to 100,000 or 150,000 per c.c. at times in cities such as London and Paris. Condensation nuclei are formed in various ways, one being the household fires and factory chimneys which produce large quantities of nucleus-forming material, chiefly sulphurous oxide. In England something like 5000 tons of sulphur are burnt each day in coal fires, giving enough sulphur products to pollute the atmosphere of the whole of Great Britain. Haze and mist, though so much alike in appearance, appear to be fundamentally different, haze owing its origin to foreign matter and a small amount of water, while mist is due to an actual precipitation of water from vapour to liquid. On the other hand, there appears to be no fundamental difference between mist and fog, fog is generally only a dense mist. Above the fog temperature inversion prevents all upward motion of the air and the smoke made by large towns is kept fairly stationary and within a few hundred feet of the ground. Clouds, rain, thunderstorms, hail, snow, and other aspects of weather are so often topics of conversation that Dr. Simpson's authoritative discourse upon them will be welcomed by all scientific readers.

THE nomination of Sir David Bruce as president of the British Association for the meeting in Toronto next year is a well-deserved honour which will be gratifying to the many friends and admirers of this distinguished scientific investigator. Sir David belongs to the Royal Army Medical Corps, and early in his career made a name for himself by cultivating the *Micrococcus melitensis* and establishing its causative relationship to Malta fever by reproducing the disease in monkeys. Later, in 1904, he was the leader of the Royal Society's Malta Fever Commission, which made the important discovery that fifty per cent. of the goats in Malta were infected and ten per cent. of them excreted the micrococcus in their milk. Within a year of prophylactic measures based on this fact being put in force, the cases at Malta fell to one-tenth of the former numbers, and since that time the Navy has been practically rid of one of the main causes of sickness in its personnel. Of still greater interest and importance are Sir David's patient and well-thought-out researches on the greatest obstacle to the civilisation of tropical Africa, tsetse-fly disease of animals and man. His demonstration of the *Trypanosoma Brucei* as the cause of the fatal tsetse-fly disease of cattle and horses in 1894 paved the way for his demonstration in 1903 that "sleeping sickness is, in short, a human tsetse-fly disease," by a wonderfully well conceived and worked-out experiment carried out as leader of a series of Royal Society Commissions working in Africa over a number of years. The etiology of two of the most important tropical fevers was thus elucidated by his investigations, with widespread results. Sir David is characterised by the thoroughness of his work and the intuition he has always brought to bear on every problem he has tackled. He is very fortunate in his helpmeet, Lady Bruce, who has shared in both the hardships and the scientific work of his many African expeditions.

FIFTY years ago, on April 18, 1873, Justus von Liebig died at Munich at seventy years of age. In 1824, at the early age of twenty-one, he began his career as professor of chemistry at Giessen and he devoted the first twenty years of his academic work to researches in the field of organic chemistry and in developing and perfecting practical laboratory instruction. The results of these labours quickly met with general recognition, and on his first visit to England Liebig was referred to by Faraday, at the meeting of the British Association at Liverpool in 1837, as one of the greatest of living chemists. Great difficulties had to be overcome by Liebig when he began to extend his theoretical and practical work to biological problems. In 1840 he published "Organic Chemistry as applied to Agriculture and Physiology," and in 1842 "Animal Chemistry, or Organic Chemistry as applied to Physiology and Pathology." The doctrines of the nutrition of plants and animals contained in these epoch-making works were at first rejected by chemists, physiologists, and agriculturists, but most of them were established in the course of the following years. Liebig's view that plants build up their organic parts exclusively from the carbon dioxide of the air and the water contained in the atmosphere and the soil, and that in intensive agriculture the mineral substances, especially potash, phosphoric acid salts, and nitrogen compounds, must be supplied to the soil in the form of artificial fertilisers, in addition to natural manure, was first accepted in England. After Liebig had modified his original opinion that the artificial fertilisers must be fairly insoluble in order not to be washed away by the rain, having recognised the extent to which the soil is capable of absorbing these substances, his doctrine of artificial fertilisation was generally accepted and forms the foundation of modern agriculture. In 1864 and 1865 Liebig wrote, at the request of the Lord Mayor of London, important papers on the utilisation of the sewage of London. Other widely-known publications are those on meat extracts, baking methods, soup for infants, silver mirrors, etc. Liebig gave a popular exposition of his views in his "Familiar Letters on Chemistry," a work from which many students of science have derived interest and inspiration.

THE season's excavations at Ur of the joint expedition of the British Museum and the University of Pennsylvania closed early in March. The chief results were described by Mr. C. Leonard Woolley in a lecture, reported in the *Times* of April 2, which he delivered at Bagdad before leaving for England. The excavations were made in a walled enclosure, resembling a citadel, within the walls of the city, in which the most prominent building was a *ziggurat* of four stories, the tower of the Temple of Nanna, the Moon god, completed about 2250 B.C., and coated with blue glazed bricks by Nabonidus about 550 B.C. One of the most interesting finds was a headless diorite statue of Eannatum, King of Lagash about 2900 B.C., which may have been a trophy of war. From its earliest beginnings, possibly in 3600 B.C., until it was altered by Nebuchadnezzar in about 600 B.C., the plan of the Temple remained unchanged. The find of a golden statue in a small temple at the foot of the tower indicates that this monarch introduced a change in ritual, to which reference is made in the book of Daniel, and brought the god from the seclusion of the sanctuary out into the open to be an object of public worship and veneration.

A QUESTION agitating workers in several branches of science at the present day rather more intensely than usual is the furnishing of an adequate guide to the growing volume of published work. The lapse of the International Catalogue and the great increase in the costs of production have made the situation acute. It has long been recognised that there is a vast amount of overlap and of wasted effort, and that, if only the various societies and publishing bodies would combine, they could provide a better service at less cost. This was the line followed by Dr. J. R. Schramm, of the National Research Council, Washington, in a recent lecture on the indexing of biological literature (*Science*, November 3, 1922). He held up *Chemical Abstracts* as the example to be followed, and considered that the Federation of American Biological Societies, to which we have previously referred, could produce a similar *Biological Abstracts*, equally complete, at an annual expenditure per member of 6 to 8 dollars. Dr. Schramm, it will be seen, believes that abstracts are what the workers want. Prof. Cockerell, in his comments on Dr. Schramm's proposals (*Science*, January 5, 1923), seems to prefer an analytical index, such as is furnished by the "Zoological Record." We agree with Prof. Cockerell; but, apart from that, the question is: Will a sufficient number of individuals be prepared to pay? The experience of the "Zoological Record" suggests that they certainly will not. This, however, may in part be due to the existence of the many competing, though less complete, abstracts and indexes, and in part to the ignorance and inertia of the workers. If, not only the American societies, but also the biological societies of the whole world, would federate for this purpose, so that the proposed *Record* or *Abstracts* were virtually the only one in existence, and were thus inevitably brought before each individual worker, then success would be assured. But that "if" implies the suppression of vested interests and of the nationalism which hampered the International Catalogue.

THE theory of the tides is a very strong source of attraction for a certain group of unscientific speculators. One of the latest of these to put his ideas into print is Mr. Evan McLennan, of Oregon, from whom we have received a pamphlet entitled "Nature Notes, Critical and Constructive." After betraying a complete misunderstanding of the theory of the tide-generating force on the principle of gravitation, he remarks, "It would, quite probably, be regarded as a far greater violation of the principles of science to question the theory of gravitation than to swallow the inconsistency," and "Of the forty federal institutions established by our own Government alone for the purpose of scientific research and the increase and diffusion of knowledge, and of the more than 1500 investigators paid from the public treasury to do this work, there is in all probability not one who could be induced by an outsider to give the slightest attention to any vital criticism of the Newtonian theory of gravitation." We can assure Mr. McLennan that in his own country alone there is a large number of scientific men who would enthusiastically give their attention to any real inconsistency in the accepted theory of gravitation.

THE Corn Sales Act came into force on January 1, so that it is no longer possible for buyer and seller of corn in Great Britain to misunderstand each other as to the particular kind of stone in which a transaction had been conducted. All such transactions must now be in cwts. of 112 lb. The Union of South Africa has, according to the March issue of the *Decimal Educator*, adopted the cwt. of 100 lb., so that the same kind of difficulty is likely to be felt in dealings between South Africa and this country as we have just avoided here with regard to corn. In both cases the Decimal Association advises the use of the 50-kilogram standard, which is approximately 110 lb. In the same way, to overcome the difficulty of the American gallon being only about five-sixths of the British gallon, the Association and the Metric Association of America recommend the introduction of the litre for all trade in liquids. With regard to our coinage, the Decimal Association is concentrating its efforts on the introduction of a high-value penny, of which 10 would go to a shilling, and the withdrawal of the threepenny-piece. In place of the latter a double-penny nickel coin would be issued. It is not proposed that new penny coins should be issued.

THE annual meeting of the Iron and Steel Institute will be held at the Institution of Civil Engineers, Westminster, on Thursday and Friday, May 10 and 11. The Bessemer medal will be presented to Dr. W. H. Maw, and the award of the Andrew Carnegie research scholarship for 1923 will be announced.

Twenty-four papers will be presented during the meeting, and their subjects will be announced in the Diary of Societies in NATURE.

THE May lecture of the Institute of Metals for the present year will be delivered by Dr. W. Rosenhain at 8 o'clock on Wednesday, May 2, at the Institution of Mechanical Engineers. The subject will be "The Inner Structure of Alloys."

THE Hansen prize for distinguished microbiological work has been awarded this year by the committee of Danish trustees to Dr. E. J. Allen, director of the Marine Biological Association's laboratory at Plymouth, for his experimental researches in marine microbiology. It will be remembered that this award, to which we referred in our issue of February 3, p. 156, consists of a gold medal and a sum of 2000 kroner. Dr. Allen has been invited to visit Copenhagen to receive the medal and to deliver a lecture on his work on May 1.

A WELL-PRESERVED rib of the gigantic dinosaur, *Cetiosaurus leedsi*, obtained by the late Mr. Alfred N. Leeds from the Oxford Clay near Peterborough, has just been added to the other remains of the skeleton exhibited in the geological department of the British Museum (Natural History). The rib measures six feet in length, and is remarkable for its slenderness.

THE three lectures of the series on physics in industry arranged by the Institute of Physics last year will be published shortly in the series "Oxford Technical Publications." The fourth lecture of the series, entitled "The Application of Physics to the Ceramic Industry," will be delivered by Dr. J. W. Mellor on Wednesday, May 9, at 5.30 P.M., at the Institution of Electrical Engineers. Other lectures will be delivered later by Prof. C. H. Desch on "The Physicist in Metallurgy," and by Dr. A. E. Oxley on "The Physicist in the Textile Industries."

As no Bill providing for a period of Summer Time was passed by the French Chamber of Deputies before adjourning for the holidays, the French Government has decided not to define such a period this year, but merely to take particular measures in regard to holiday and health resorts.

THE seventy-sixth annual meeting of the Palæontographical Society was held on March 31 in the Geological Society's rooms, Burlington House, Mr. E. T. Newton, president, in the chair. The annual report of the council referred to the reduction in the size of the society's annual volume owing to increased costs and smaller membership, but announced the early beginning of new monographs of Malacostracous Crustacea, by Mr. Henry Woods, and of Gault Ammonites, by Dr. L. F. Spath. Contributions had been received towards the cost of plates from the University of Bristol and from Mr. F. W. Harmer. Messrs. A. J. Bull, E. Heron-Allen, H. B. Milner, and A. Wrigley were elected new members of council. Mr. E. T. Newton was re-elected president, and Mr. Robert S. Herries and Dr. A. Smith Woodward were re-elected treasurer and secretary respectively.

A NOTE on cleaner air for London appears in the *Meteorological Magazine* for March. The Public Control Committee of the London County Council is considering how far fog in London is the result of atmospheric pollution due to preventable causes, and how far the atmosphere may be improved by the larger use of electricity for power and other purposes. It is also being considered whether further powers are required to deal with the emission of smoke. Detailed reports have been prepared, and these appear to be under discussion by the Council.

A NEW type of pocket magnifier is now included in the optical products of Messrs. Cooke, Troughton and Simms, Ltd., Buckingham Works, York. We have had an opportunity of examining one of these. The lens consists of an achromatic doublet giving a magnification of five with a focal length of 2 in., an aperture of 0·85 in., and a field of view of about 2 in. in diameter. The field is flat and free from distortion and colour, and the definition is good over the whole of it. The lens is fitted in a duralumin mount which can be folded when the magnifier is not in use. Magnifiers of this type are now being supplied with powers of 2½, 5, and 10 respectively.

BEGINNERS in bee-keeping will find some useful information in Leaflet 128, recently revised by the Ministry of Agriculture and Fisheries. Bee-keeping is an occupation eminently suitable for small-holders, cottagers, and others with only a limited space available. The insects are, moreover, active pollinators of fruit blossoms, and consequently have other uses besides the production of honey. Having mastered the contents of this leaflet, we advise the beginner to procure the collected leaflets on bee-keeping (seven in number), which can be obtained from the Ministry, at 10 Whitehall Palce, S.W.1, at the low price of 6*d*., post free.

THE Gifford Emonds prize, value 100*l*., which is awarded every two years for an essay on a subject dealing with ophthalmology and involving original work, and open to any British subject holding a medical qualification, is now open to competition. The subject chosen is "Iridocyclitis." Preference will be given to original work based on any branch of the subject, rather than to compilations of the writings of previous observers. Full particulars of the prize can be obtained from the Secretary Superintendent, Royal London Ophthalmic Hospital, E.C.1. Essays must be sent in not later than December 31, 1924.

MESSRS. H. SOTHERAN AND CO. (43 Piccadilly, W.1) have recently purchased and are offering for sale as a whole the library of books on British ornithology formed by Major W. H. Mullens. It contains about 3000 volumes, and ranges from the "Avium praecipuarum" of William Turner, 1544, to Beebe's recently completed "Monograph on the Pheasants."

THE catalogues issued by the firm of Bernard Quaritch, Ltd., 11 Grafton Street, W.1, are always of interest. The latest one (No. 376) contains upwards of 1700 titles (with, in many cases, comments) of books in the following subjects: botany, agriculture, early medicine and surgery, forestry, fruit-culture, gardens and gardening, herbals, and tobacco. As usual, many choice and rare volumes are included.

No. XI. of the "Publications de la Société de Chimie Physique" is a short monograph of 15 pages on isotopes, by M. Maurice de Broglie, which was delivered as a lecture in November 1920. The previous publication was a lecture on Bohr's theory of the constitution of the atom. The monograph is published by Hermann et Cie at the price of 2 francs. Two series of somewhat similar monographs are being issued by the Libraire Scientifique Albert Blanchard. One of these, of which seven parts are announced, consists of groups of two or three lectures on physical subjects. In addition to these a series of foreign scientific monographs is being issued. The third of these, which has recently come to hand, is by Prof. Kossel, and bears the title "Les Forces de Valence et les Spectres de Röntgen." The monograph covers 70 pages, and is issued at a price of 4·50 francs.

The Society of Glass Technology, which has its headquarters at the University of Sheffield, has issued a useful handbook, a "Directory for the British Glass Industry," price 7*s.* 6*d.* to non-members of the Society. The volume is divided into sections providing lists both alphabetical and classified of glass manufacturers and craftsmen, with particulars in most cases of the class of work produced, and lists of firms supplying material and machinery required in glass making and working. The concluding short sections give useful information concerning industrial associations, trades unions, City Companies, educational institutions, and research associations, and publications dealing with glass technology. It is difficult to understand on what principle the selection of a group of publications, mentioned in the last section, which are referred to as "Periodicals in which articles on glass and ceramics occasionally appear," has been made.

Our Astronomical Column.

A Supposed Meteorite at Quetta.—The *Pioneer Mail* for February 23 reports the fall of a supposed meteorite at Quetta on January 25, which, if confirmed, will for the first time establish the power of a meteorite to cause a conflagration. The fragments of the meteorite collected are said to weigh 6 tons, with a volume of 500 cubic feet! Hence the material must be abnormally light for a meteorite. It struck a large stack of closely packed straw 30 feet high, and penetrated it nearly to the ground. The "meteorite" is said to consist of materials like slate-grey igneous rock, volcanic glass, and coke. Possibly the stack was struck by lightning and the fused residue of the straw has been mistaken for a meteorite. The Geological Survey of India will doubtless settle the nature of this phenomenon.

Solar Eclipse Investigations.—At the meetings of the Australasian Association for the Advancement of Science held at Wellington, N.Z., two papers dealing with observations of the total solar eclipse at Wallal were communicated by Prof. A. D. Ross, who was a member of the Crocker Eclipse Expedition of the Lick Observatory. Shadow bands were observed for two minutes before and for one minute after totality. They altered in appearance, but the most persistent type was indistinct dusky bands about 6 inches wide, at 17-inch intervals, moving in a direction 30° S. of E. at 6 or 7 miles per hour. The bands at times came in groups and developed from a general shimmering effect. Their appearance was inconsistent with a diffraction theory, but suggested irregular refraction due to atmospheric temperature inequalities. The wind was from N.N.W. to N.W. at about 4 miles per hour, and there was a temperature drop of about 8° due to the eclipse. By comparison of six photographic plates exposed to a region surrounding the south celestial pole about mid totality and during twilight the same evening, it was found that the eclipse illumination corresponded to twilight with the sun 7½° below the horizon. Wellington Anti-screen plates were used. The humidity was about 45 per cent. at the time of totality and about 50 per cent. at twilight, so that it is unlikely that the estimate of brightness was much affected by variation in the transparency of the atmosphere. Determination of the brightness of the corona was attempted with a specially designed integrating photometer, but the measurements of the plates had not been completed.

Planetary Radiation.—No. 460 of the Scientific Papers of the Bureau of Standards, Washington, contains an account of researches made at Flagstaff by W. W. Coblentz on the thermal radiation from planets and stars. A cell of water 1 cm. thick is used to separate the long heat-waves from planets (due either to inherent heat or to warming of the surface by the sun) from the reflected solar radiation. A vacuum thermocouple made of bismuth wire was used to measure the radiations, the instrument being mounted on the 40-inch reflector. Observations on the moon are stated to confirm Very's results, but are not described in detail.

The observations lead to the conclusion that the planetary (long wavelength) radiations, expressed as percentages of the total radiation received from them, are Jupiter (0), Venus (5), Saturn (15), Mars (30), the moon (80). The high figures for the moon and for Mars indicate that rarity of atmosphere increases the warming of the surface; further, the northern hemisphere of Mars, which was in autumn, and more cloudy than the southern hemisphere, indicated a lower planetary radiation. It is hoped to compare the radiation from the orange and dusky regions of Mars, which might give a clue as to the conjectured interpretation of the latter as regions of vegetation.

The zero figure for Jupiter is concluded to be due to the enormously thick atmosphere, which acts as an opaque screen to the radiations from the (supposed) heated interior. The instrument is restricted to wavelengths 7 to 12 μ. Hence nothing can be stated about radiation between 4 and 7 μ, or from 12 to 15 μ.

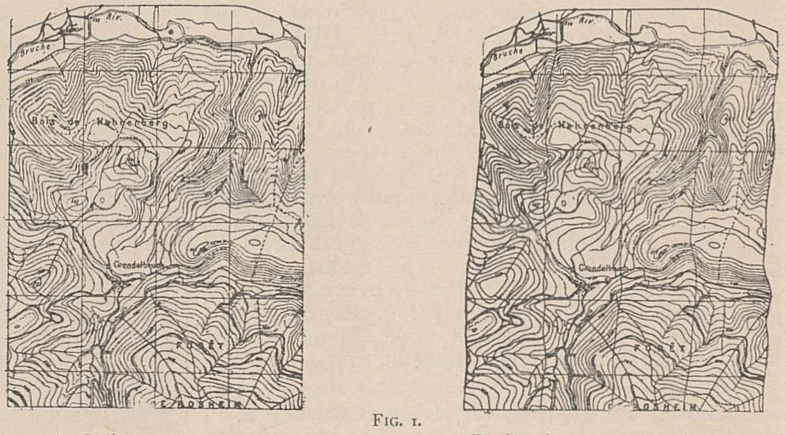
The star temperatures are given as 3000° for type M, 5900° for Capella and sun (type G), and 12,000° for type B, in close accord with previous results.

Research Items.

Migrations of the Waxwing.—The waxwing, *Ampelis garrulus*, is not a rare visitor to our shores. Seldom a winter passes but one or more is observed in eastern parts of Britain, and occasionally its numbers indicate a very considerable immigration. The largest ever witnessed in Scotland occurred in the late autumn of 1921, and is discussed by Dr. J. Ritchie in the *Scottish Naturalist*, September 1922–February 1923. The immediate cause of Scotland's share in this immigration is due in the first place to the lack of food-supply in Norway. The summer of 1921 in that country has been notorious for the lack of wild berries upon which the waxwings feed. Large flocks of the birds congregated in the southern part of Norway, but, finding insufficient food, took advantage of easterly winds accompanied by a rapidly rising barometer to reach our shores. The meteorological phenomena associated with the migration are complex, and Dr. Ritchie promises to deal with them in a future paper.

Botanical Survey and Ecology in Yorkshire.—Under this title a most valuable and comprehensive account of the development of our knowledge of the Yorkshire flora is given by Dr. T. W. Woodhead in the *Naturalist* for March 1923. The first flora of Yorkshire was published at Halifax in 1840 by Henry Baines, and since then the three Ridings have been more intensively dealt with in the three well-known floras, Baker's "North Yorkshire," Arnold Lee's "Flora of West Yorkshire," and Fraser Robinson's "Flora of the East Riding of Yorkshire." Many other valuable systematic works dealing with the Yorkshire flora are described by Dr. Woodhead, who then proceeds to narrate the development of botanical survey and the mapping of plant associations, under the inspiration of the brothers Robert and William G. Smith. Around these men an active band of workers gathered, and in December 1904 the Central Committee for the Survey and Study of British Vegetation was formed at a meeting held at the house of Dr. W. G. Smith in Leeds; in 1913 this Committee was replaced by the British Ecological Society with its wider membership. Two vegetation formations that have been extensively studied in Yorkshire are the woodlands and the moorlands, and Dr. Woodhead briefly traces the development of our knowledge of these characteristic vegetation features, their distribution, development and occasional retrogression. There is an interesting discussion of the significance of the vegetation found in the peat of the Southern Pennines, and the bearing that the studies have upon persistence of the flora from pre-glacial times. Dr. Woodhead's work upon the relation of vegetation survey to the many other activities and interests of a district was well illustrated by the extraordinarily interesting series of maps of the Huddersfield area that were on view in Hull during the British Association meeting, in the exhibition room of the Yorkshire Naturalists' Union. It is therefore natural to find that the presidential address to the Yorkshire Naturalists' Union closes with the expression of a hope that such ecological studies may extend to man, and that the local museum may enshrine the results of an intensive local survey of plant and animal, including human communities.

A New Process for making Stereoscopic Maps.—A paper read at a recent meeting of the Paris Academy of Sciences (*Comptes rendus*, January 22) described a new method, due to M. G. Poivilliers, for obtaining stereoscopic maps. The various methods proposed hitherto have been based on the use of two conical perspectives, the production of which involves practical difficulties; in M. Poivilliers's method two cylindrical projections are used, one vertical and the other oblique. Referring to the accompanying illustration (Fig. 1), the projection A is an ordinary contour map; the projection B is obtained from A by shifting the contour lines in the direction east-west by an amount proportional to their altitude above an arbitrarily chosen datum line. The resulting stereoscopic view shows theoretically a slight curvature effect which, however, does not alter the relative relief. In examining with a stereoscope even the above reproductions, the result obtained is very striking. The "falsified" map B was in this case drawn by hand with the aid of a tracing of A, but it is easy to imagine a simple apparatus by means of which this can be done semi-automatically. The contour interval is in this case 20 metres, and corresponds to a horizontal shift of 0·5 mm. It is anticipated that M. Poivilliers's method, on account of its simplicity, will tend to generalise the use of stereoscopic maps, especially for purposes of instruction in topographical surveying. It has also been suggested that the process could be usefully applied to geological maps, by making it possible, for example, to visualise the superposition of successive layers inside the earth.



A—Ordinary contour map.

Fig. 1.

B—Complementary map, with contour lines displaced.

Atmospheric Humidity in the United States.—Prof. R. de C. Ward, of Harvard University, is the author of a communication on the above subject in the U.S. *Monthly Weather Review* for November 1922. The communication is admirably illustrated with diagrams; two are given for January, at 8 a.m. and 8 p.m., and two for the corresponding hours in July, showing the relative humidity by lines of equal value over the whole of the United States. The element is a real and definite factor in climate, and especially affects our bodily comfort. The values give the ratio between the amount of moisture in the atmosphere and the amount which could be present without condensation. On the Pacific, Atlantic, and Gulf coasts the lines show a distinct tendency to be parallel to the sea-coast. The distribution is chiefly controlled by temperature, direction of prevailing winds, distance, and direction of the chief source of moisture supply, and general topography. Charts given with the communication are taken from the " Atlas of American Agriculture." A belt of uniformly high relative humidity along the coasts averages about 75-80 per cent., and at times exceeds 90 per cent. on the Pacific coast. Inland, in parts, the minima relative humidity during the hot summers fall to 30 per cent., and even 20 per cent. over the districts of most extreme aridity. Absolute humidity, which shows the actual amount of water vapour in the air expressed in decimals of inches, and known as vapour pressure, is also dealt with; two charts are given showing the equal pressure lines over the United States in the months of January and July. Temperature is essentially the chief control of absolute humidity; in mid-summer the amount of moisture in the atmosphere is generally from two to four times as great as in mid-winter.

GEOLOGY AND THE ICE-CAP IN NORTHERN GREENLAND.—The interest of Dr. Lauge Koch's geological mapping in Northern Greenland (NATURE, vol. 110, p. 91) is now increased by his preliminary account of Peary Land. His new map (*Am. Journ. Sci.*, vol. 206, p. 190, 1923) shows the continuation of the Caledonian folding through the north of the region, where moraine-matter from the glaciers descending from the south obscures much of a country in any case difficult for research. The ice-cap extended a good deal farther north at the maximum of the Pleistocene ice-age, but did not cover all the coastland. It may be remarked that in this area we have once more evidence of the potency of snow-domes in promoting widely spread glaciation. It seems unnecessary, if unfashionable, to shift the pole to account for every local centre of ice-radiation. The main result of Lauge Koch's recent work is the discovery of a richly fossiliferous Ordovician series far greater in extent and thickness (870 m.) than he could anticipate when he began his arduous explorations in 1917.

PRODUCTION OF LEAD IN BRITAIN.—In the numbers of *Chemistry and Industry* for March 16 and 23, Prof. H. Louis contributes a most interesting and valuable account of the production of lead in Britain. He begins with a clear account of lead in ancient times. The first definite mention of the production of lead in Britain occurs in Pliny (A.D. 77); a pig of lead has been found in the Mendip Hills bearing the name of the Emperor Claudius (A.D. 49), and in A.D. 64 smelting in Flintshire began. Some pigs of Roman lead are stamped *ex arg.*, *i.e.* desilvered—probably by cupellation. The progress made in the Middle Ages is described in detail by Prof. Louis, whose articles have a wide interest.

SUBSTITUTION IN THE BENZENE NUCLEUS.—In the *Chemical News* of March 16, Messrs. R. Fraser and J. E. Humphries discuss the problem of substitution in the benzene nucleus in the light of the Lewis-Langmuir theory of co-valence. They start from three simple postulates related to the octet stability of an atom or group, and discuss in an interesting manner many known results in organic chemistry. In the chaotic mass of unco-ordinated facts which lies heavy on organic chemistry a ferment is evidently moving; in time the material will no doubt be brought into order, and discussions of the type of that mentioned cannot fail to be of service in this direction.

EARLY HISTORY OF THE GAS PROCESS.—The early history of the manufacture and distribution of towns' gas was briefly outlined by Mr. D. Brownlie in a paper read before the Newcomen Society on March 20. Van Helmont, in 1600, observed that " coal did belch forth a wild spirit or breath." Other early pioneers include Thomas Shirley (1667), Robert Boyle (1691), Stephen Hales (1726), J. Clayton (1739), Bishop Watson (1781), the Earl of Dundonald (1781), and Minckelers (1784). William Murdoch lighted his house at Redruth with coal gas in 1792. At first the gas was burned at the open end of an iron pipe, but the accidental use of an old thimble led to the introduction of a burner in which the gas was lit at a number of jets issuing from a perforated thimble. Messrs. Boulton and Watt's works at Soho, Birmingham, were illuminated by gas in 1802. The plant erected by Murdoch for this purpose differed in little but scale from the horizontal settings and gasometers of to-day. Lebon, in France, worked along much the same lines as Murdoch, and illumined his house with coal gas in 1801. Winsor illumined part of Pall Mall with gas in 1807. Samuel Clegg introduced lime purification in 1806, and invented the first gas-meter in 1815. In the early days gas was distributed through lead or wood pipes. Cast-iron pipes were introduced in 1810, and wrought-iron pipes in 1825. John Grafton, in 1820, introduced the use of fireclay instead of iron for retorts. This permitted the temperature of carbonisation being raised from 1400° F. to 2000° F. Clegg patented retorts for continuous carbonisation in 1815. The first vertical gas retort was patented in 1828 by John Brunton.

PHOTOMETRY.—In his annual address before the Philosophical Society of Washington, the retiring president, Mr. E. C. Crittenden, presented an interesting survey of problems involved in the measurement of light. The address has appeared in the Journal of the Washington Academy of Sciences (vol. 13, No. 5, March 4, 1923). In the introduction Mr. Crittenden recalls several notable advances in photometry, such as the adoption of the international unit of candle-power by all leading countries except the Germanic nations. In view of the uncertainties attending the use of flame standards, this unit is now usually preserved by the aid of calibrated electric incandescent lamps; the process is analogous to that adopted for the international ohm, derived from a mercury standard but maintained by means of wire resistances. However, there is this important distinction, that we have as yet no adequate, accurate, and reproducible primary standard of light. One of the most hopeful lines of investigation is that pursued at the U.S. Bureau of Standards, where experiments on a black body maintained at a definite temperature have been made; the black body takes the form of a carbon-tube electric furnace matched in colour by comparison with certain standard incandescent lamps. But further information on the accuracy with which temperature can be maintained is needed. The address also directs attention to the fundamental distinction between conceptions of light as radiation, and as a physiological impression—a distinction that becomes specially important when we have to deal with sources yielding light of different colour. The physiological phenomena affecting such comparisons are discussed, and some remarks are made on the results of " equality of brightness " and " flicker photometer " measurements. The visibility curve, throughout the spectrum, of the normal eye has now been ascertained with fair precision. A knowledge of this should enable us to evaluate the luminous power of any variety of radiant energy; and if, in addition, the primary standard based on the black body at specified temperature should prove satisfactory, considerable progress towards the scientific measurement of light will have been made.

Biometry and Genetics.

PROF. RAYMOND PEARL and his students continue to make important contributions to the biology of man and other organisms on a statistical basis. In a recent paper (Pearl and Bacon, Johns Hopkins Hospital Reports, vol. xxi. Fasc. iii.) an analysis is made of the relation of the relative size of heart, liver, spleen, and kidneys to tuberculosis. The data were derived from 1341 autopsies in which there were tubercular lesions. Six indices for the relative weights of the above organs were used as the basis of statistical investigation in relation to age, sex, race, and cause of death. It is shown that the relative weights of liver and heart, and heart and spleen change progressively during life; also that in cases of fatal tuberculosis the absolute weight of the heart is less and of the spleen greater than normal, probably because these changes are brought about by the disease. Curves of age show that when tuberculosis alone is fatal it kills at comparatively early ages. Many other interesting facts are brought out in this statistical study.

In "dry" America, experiments with alcohol have a particular interest. Stockard has shown with guinea-pigs and Pearl with fowls that individuals which throughout life received daily doses of alcohol by inhalation are much longer-lived than their untreated sibs. In a recent note (*Amer. Journ. Hygiene*, vol. ii. No. 4) Prof. Pearl points out that the actuarial data of insurance companies, which are generally supposed to show that the consumption of alcohol in man in any quantity shortens life, are practically worthless. From 1569 family history records carefully collected in the vicinity of Baltimore, he concludes that while heavy or steady drinking lowers the expectation of life, the moderate or occasional consumption of alcohol has no such effect on either sex.

In experimental studies on the duration of life in Drosophila (Pearl and Parker, *Amer. Naturalist*, vols. 55, 56) the authors compare the percentage of survivals at successive ages with the corresponding curve for man. A day in the life of a fruit-fly corresponds roughly with a year in the life of a man. Large numbers of flies of different stocks were bred under carefully standardised conditions. The length of the imaginal life was noted and the results compared with the statistics for man, beginning at the age of fifteen years. Fundamentally similar curves are obtained in the two cases. In Drosophila it is shown that long-winged flies have two or three times as great an expectation of life at any age as short-winged flies, and that other hereditary differences in duration of life also occur. The death-rates generally increase steadily with advancing age. The mortality curve for Drosophila is then compared with that for modern man and for the population of the Roman provinces in Africa about the beginning of the Christian era (from data of MacDonnell, *Biometrika*, 1913). The Drosophila curve generally runs intermediate between these two. The modern curve of human mortality is diverted from the normal by the prolongation of life of many of the less rugged by measures of public health and sanitation.

By selection and inbreeding from Drosophila stocks it was possible to isolate strains showing large differences both in mean duration of life and in the form of the mortality distributions, while in inbred lines the genetic differences remained constant for ten to twenty-five generations. It was shown that occasional etherisation of the flies has no appreciable effect in lessening their duration of life. There is some evidence that in crosses, duration of life may segregate like a Mendelian character. A pedigree indicating something of the same kind in man is presented by Pearl (*Amer. Journ. Hygiene*, vol. ii. No. 3). In the father's family only 10 per cent. survived to the age of fifty years, in the mother's family 75 per cent. reached that age, and in the offspring 87·5 per cent.

Using 100 births/deaths as a "vital index," Pearl and Burger (Proc. Nat. Acad. Sci. vol. 8, No. 4) plot the curve for this index for England and Wales in the years 1838–1920, from statistics in the Annual Reports of the Registrar-General. This ratio shows a slow but extremely steady increase until 1914, with only two slight fluctuations caused by influenza epidemics in 1847 and 1890. The birth-rate in the meantime showed a slow increase until about 1878, then a more rapid decrease until 1914, and a marked recovery since the war. Thus while in the year 1838–39 the number of births for each death was 1·4, in 1920 it was more than 2. The whole curve for the vital index shows a remarkably steady increment in the rate of population growth, with a high degree of regulation of death-rates to variations in the birth-rate. Measured by the criterion of the vital index, it is concluded that the population of England and Wales is "biologically more vigorous" than in 1838. But this merely means that its net rate of increase is greater, and takes no account of the differential character of the birth-rate. In another note in the same issue, Pearl considers the seasonal fluctuations in the vital index of the population, based on the same data, and finds that in each year it has its lowest value in the winter quarter (ending March 31), and its highest value in the summer quarter. In other words, in the winter months the birth incidence is relatively low and the death incidence relatively high, as might be expected.

That density of population influences fecundity was formerly shown for fowls, and similar results have now been obtained for Drosophila (Pearl and Parker, Proc. Nat. Acad. Sci. vol. 8, No. 7). The rate of reproduction of this fly is shown experimentally to vary inversely with the density of population. This is the converse of Farr's law that the death-rate varies directly with density of population. It is suggested that the world-wide increase in density of population may account for the general decline in birth-rates which has taken place in the last forty years. The subject is one which deserves further investigation.

A hexadactylous Norwegian family in which the postaxial digits (little fingers and toes) are double, is described by Aslaug Sverdrup (*Journ. Genetics*, vol. xii. No. 3). The condition is traced through six generations, and two types of polydactylism are recognised. In type A one finger, usually the fifth, is duplicated, while in type B the sixth finger is represented by a small attached appendage. Both these types are already well known. The condition behaves in general as a dominant character, but in one line of the family, showing chiefly the A-type, there is an excess, and in another, showing only the B-type, a deficiency of polydactyls. Moreover, an A-type individual may have either A- or B-type offspring, whereas B-types cannot produce A-types. It is concluded that the B-type is probably determined by a single Mendelian factor with sometimes a failure of dominance, while the A-type is probably due to cumulative factors. The A-type of polydactyly is sometimes accompanied in this family by a form of brachydactyly due to shortening of certain metacarpal bones, but also in some cases to short phalanges. Such papers on the inheritance of human abnormalities are important in their recognition of the necessity for accurate and detailed observations.

In a study of the inheritance of patching in the flower of the sweet pea Prof. Punnett (*Journ. Genetics*, spoken. But whereas in Norway the entrance of foreign words is not resented, in Iceland they invariably undergo translation before acceptance. The writer was given to understand that the language is written and spoken in almost exactly the same manner as it was a thousand years ago, and that the ancient sagas can be read with the same ease as the modern newspaper. Probably there is no other country in Europe where this strange perpetuation of ancient forms of speech prevails.

The Survey of India.

THE report by Col. Ryder, the present Surveyor-General of India, referred to below,[1] shows that in the year 1919–20 the Indian Survey Department had fully recovered from the dislocation due to the War.

During this period there were no less than 19 survey parties in the field, of which 12 were topographical. On the normal scale of one inch per mile (much of which was revision) and smaller geographical scales, about 2800 square miles was turned out, while on the larger scales, ranging from 1½ inches to 24 inches and even 64 inches (city and town surveys), the output, detailed partly in miles and partly in acres, was reckoned to be satisfactory. Every class of country was included in the field of work, from the sands of Rajputana to the dense forest-covered hill tracts of Burma, and we read of the time-old difficulties, heavy and continuous rain, malaria, and even of the clearance of villages by man-eating tigers. It is interesting to observe that the sources of the Irawadi (so long a geographical problem) were finally mapped.

Although the costs of the different classes and scales of survey are set out in considerable detail, it is difficult to frame any conclusion as to whether those costs have risen since the War. The normal one-inch scale of original survey apparently varied between 20 Rs. per square mile in Bengal and 70 Rs. in Lower Burma. This does not indicate any great increase on pre-war costs, but in itself scarcely justifies any general estimate.

In the geodesic and scientific branch of the department there is a curtailment of activity. No first-class triangulation was carried out, and both the pendulum and latitude observations were suspended, but the registrations of tidal curves by means of self-registering tide-gauges were continued at Aden and at the principal ports of India. Levelling operations were also continued, and a new geodesic level net of India has been inaugurated on which levelling of high precision on the "fore and back" system will be the method employed. Like the exact determination of the height of the principal peaks of the Himalaya, it might be open to question whether the practical results of extreme precision are worth the expense of determination. The magnetic survey was also carried on during this season. The report closes with the usual returns of the computing- and drawing-offices.

The chief point of interest in the volume is found in Appendix II.—the report on the expedition to Kamet by Major Morshead, who afterwards took such an active part in the Everest expedition. Kamet (25,445 feet high) is the culminating peak of the Zaskar range, and afforded Major Morshead and that distinguished mountaineer, Dr. Kellas, an excellent opportunity for scientific observation on the effect of high altitudes on the human body. Appendix III. is also interesting, recording a note on the topography of the Nun Kun massif in Ladakh by Major Kenneth Mason. He has a good deal to say in criticism of Mrs. Bullock Workman's claim to have established the height and position of certain peaks of that group, in which she disagrees with Indian Survey results. It is always dangerous for the amateur to claim greater accuracy than that maintained by the Trigonometrical Survey of India. Mrs. Bullock Workman, in publishing her account of her extraordinary feats of climbing, pits herself against the G.T.S. and suffers accordingly.

T. H. H.

[1] Records of the Survey of India: Annual report of Parties and Offices for 1919–20, vol. 15.

Polish Celebrations of the 450th Anniversary of the Birth of Copernicus.

NICOLAUS COPERNICUS was born on February 19, 1473, in Toruń (Thorn), a town situated on the Vistula, in the north-west of Poland; the 450th anniversary of the birthday of the great astronomer occurred thus on Monday, February 19, and was celebrated in many parts of Poland with much solemnity. Impressive ceremonies were held in Warsaw, Wilno, Poznań, Lódź, Wloclawek, and Kieke; in the Jagellonian University of Cracow (where for four years, 1491–1495, Copernicus was an undergraduate) the celebrations in commemoration of the anniversary will be held at a later date, probably in May.

In connexion with the Cracow proceedings a work, "Stromata Copernicana," will be published under the auspices of the Polish Academy of Sciences and Letters in Cracow; its author is Prof. L. Birkenmajer, the well-known biographer of Copernicus. We have not the space to enter into an account of Prof. Birkenmajer's investigations, but the following interesting fact may be mentioned: On the October page for the year 1505 of the book "Calendarium Magistri Joannis de Monte Regio," preserved in the Uppsala University Library (sign. "Incunab." 840), Prof. Birkenmajer discovered, in Copernicus's well-known handwriting, the Polish inscription (twice repeated) "Bok pomagay" (Our Lord, help us). Writing on this interesting detail, Prof. Jan Łoś, the well-known philologist (and professor of the history of Polish language in the Jagellonian University of Cracow), says: "In the year 1505 every Pole would have written the words given above exactly in the form in which Copernicus has written them" (*Jezyk Polski*, vol. viii., No. 1). Prof. Birkenmajer adds that in 1505, or perhaps in 1506, Copernicus had already in his mind the ideas which eventually took form in the well-known revolutionary "Commentariolus."

The Copernicus commemoration at Toruń extended over the two days—February 18 and 19; delegates from all the universities, high schools, scientific societies, etc., of Poland, and other guests were cordially received by the municipality and citizens of Toruń. The proceedings included the inauguration of the first general meeting of the Polish Astronomical Society. This meeting resolved unanimously to ask the Polish nation to establish a National Astronomical Institute in Poland; an attempt with this object in view was made by Prof. Banachiewicz, of the Jagellonian University of Cracow, and exists in the form of an astronomical station in the Carpathian Mountains. A memorial tablet on the house where Copernicus was born was also unveiled.

Pathology of Market Produce.

DURING recent years great efforts have been made by the biologist to gain such a knowledge of the diseases of cultivated crops as will permit methods of control to be placed at the disposal of the grower.

A reference to the pages of the *Annals of Applied Biology*, the official organ of the Association of Economic Biologists, together with the number of other papers published each year dealing with the life history of disease-producing organisms infecting plants, will show that considerable progress has been made in this still comparatively new field. But some brief papers published in *Phytopathology*, the official organ of the American Phytopathological Society, will show that in the United States a new field of scientific investigation has been opened between the crop and the consumer. Much of the produce, especially of market garden and greenhouse, is extremely perishable, and the cost of fruit or vegetables to the consumer is largely contributed to by the heavy loss that occurs during transit and marketing.

In 1917 in the States a Food Products Inspection Service of the Bureau of Markets was established and was soon working in close collaboration with the trained investigators of the Bureau of Plant Industry.

As is pointed out by G. K. K. Link and M. W. Gardner in a brief review of the first year's work that resulted from the joint attack upon the pathology of market crops (*Phytopathology*, 9, pp. 497–520), the first result was a revelation of the enormous economic importance of the problem, to which the long distances of transit in the United States naturally contributed. In water-melons alone, from four States during 1918, the market inspection services record a loss of 1¼ million dollars, while hundreds of car loads of grapes from California were almost a total loss, due to decay induced by Botrytis, Penicillium, and Aspergillus. Furthermore it was found that these losses, stoically borne by the trade as "part of the game" and passed on to the consumer, very largely arose from preventable causes, with the result that pathologists are being pressed to extend their survey from the growing crop to the study of the crop during harvesting, storing, shipping, and marketing.

Another line of biological inquiry has also been indicated: the task of salvage when prevention of loss is no longer possible. Most of these diseases are fermentation processes, and a controlled fermentation may yield a by-product of value. At the outset the market pathologist has found himself forced to recognise almost a new type of disease organism. Under field conditions this type has limited importance, but under market conditions the plant tissues are less resistant and these organisms show much greater virulence while attacking a wide range of plant species; among such organisms are found the bacterial soft rots and Botrytis.

The American pathologist has already reached the stage at which his first survey enables him to indicate to grower and salesman the most harmful types of disease, the characters by which they may be recognised by the non-expert eye, the conditions leading to the spread of these diseases and the most practicable methods for their control during transport and storage. It may be argued that in Great Britain, the small distance involved in transit renders the question of less importance. But short distances do not always mean rapid transit, and in any case, the most casual inspection of a fruit and vegetable market would show that American experience in this question may be of real value.

Of general application also are such results of the preliminary American work as their experience with strawberries, where N. E. Stevens finds (*Phytopathology*, 9, pp. 171–177) that strawberries picked early in the day, even if wet, keep better than those berries picked after the sun has been on them for some hours. Pomologists also will be quick to admit that we have still to learn the reasons for the different keeping qualities of the same variety of apple if gathered under different conditions. Under the stimulus of war conditions very great progress was made in Great Britain in the investigation of food storage conditions, and as a consequence some attention has been paid in recent scientific communications to the organism found causing damage among stored produce. American experience, however, would seem to raise the more general question whether the phytopathological experience of the investigator should not be reorientated so as to embrace the whole history of the vegetable, from field to table.

The Eruption of Sakura-jima in 1914.

PROF. OMORI has recently (*Bull. Imp. Earthq. Inves. Com.*, vol. 8, pp. 467-525) published his sixth, and apparently last, memoir on the eruption of Sakura-jima of January 12, 1914, and following days—the greatest of all known eruptions in Japan, if greatness be measured by the amount of lava outflow and ash precipitation. The six memoirs fill a volume of 525 pages and are illustrated by 107 plates. They constitute, according to the author, "a modest geometrical and seismological report on the great Sakura-jima eruption of 1914, and the course of the after-events followed for the next 8 years." Prof. Omori's readers will, I imagine, take a somewhat different view. They are more likely to regard the volume as the finest monograph, from a physical point of view, that has ever yet been written on a volcanic eruption.

Summaries of previous memoirs have from time to time appeared in these columns.[1] The first (September 1914) contains a general account of the eruption and its accompanying phenomena. The second memoir (April 1916) deals with the sound and ash-precipitation areas of the eruption, the accompanying changes of level and the earlier outbursts of the volcano. The third (December 1916) summarises the subsequent course of activity. After a pause of more than three years, the fourth memoir (March 1920) appeared containing the results of the levelling surveys and the soundings in Kagoshima Bay made after the eruption. The fifth part (March 1920) is devoted to the seismographical observations of the fore-shocks and after-shocks, while the sixth (November 1922) deals chiefly with the destructive earthquake of January 12, 1914.

The interest of this earthquake lies in its occurrence during the eruption about 8½ hours after it began. It was clearly a tectonic, and not a volcanic, earthquake. Instead of being a sharp brief shock of small disturbed area, the movement at Kagoshima was of considerable strength and duration; it was felt for about 220 miles to the N.E. and S.S.W., and was strongly registered by European seismographs.[2] The epicentre was situated in the Kagoshima channel, about 4 km. south-east of the observatory in that

[1] Vol. 94, p. 289; vol. 98, pp. 57-58; vol. 100, p. 35; vol. 106, pp. 165-166.

[2] Nature, vol. 92, 1914, p. 717.

city. Judging from the duration (1·9 seconds) of the preliminary tremor, Prof. Omori infers that the focus was distant 14 km. from the observatory and therefore at a depth of 13 km. Numerous stone-lanterns and tombstones were overthrown in Kagoshima, the average direction of their fall being N. 68° W., which agrees roughly with the direction of the first movement registered in the same place. The trigonometrical re-survey of the district revealed horizontal movements since the eruption began of 2·62 to 4·52 metres to the north-east and north in the north and north-west parts of the island, while new soundings made in the north part of Kagoshima Bay showed that the floor of the bay had sunk from one-half to four fathoms, except in two spots in which a rise of from one to three fathoms had occurred. An hour or a little more after the earthquake, small sea-waves or *tsunami* swept over the shore at Kagoshima. At about the same time or later, the cable from Kagoshima to Sakura-jima, which crosses one of the elevated spots, was fractured on the flat bottom of the channel about one-third of its width from the coast of the island. Prof. Omori points out that it was not a single clear fracture, such as might have been formed if the application of the tension had been instantaneous, but that numerous breakages occurred over a length of 420 feet, the average distance between successive breaks being 1·7 feet. He infers that the horizontal and vertical movements of the sea-bed took place gradually.

The occurrence of a great tectonic earthquake in a volcanic district and during the progress of an eruption is somewhat rare. Prof. Omori gives some other examples from Japan in this memoir. Their connexion with the corresponding eruptions can scarcely be doubted. It seems equally clear that they do not owe their origin to the volcanic outburst itself, but that eruption and earthquake are both effects of the same deeply-seated cause.

C. DAVISON.

Fishery Research in Lancashire.

THE report on the scientific fishery investigations carried out under the auspices of the Lancashire and Western Sea Fisheries District Committee during the year 1921, which is edited by Prof. James Johnstone, the honorary director of the scientific work, is characterised by the extremely cautious way in which it has been drawn up. While the absence of very definite conclusions must to some extent be a matter for regret, it has to be admitted that the amount of evidence collected, though very extensive when considered in the aggregate, is still insufficient to make any other course possible for a highly-trained and critical mind. Like so much of the valuable fishery work which has been accomplished during the last twenty or thirty years, these investigations have tended to show how exceedingly complex the problems may become, and how difficult it is to get together data sufficiently varied in character and in sufficient quantities to provide material for their solution. The investigations do, however, afford clear indications of the lines upon which future research should proceed and make it certain that many of the questions discussed may be answered in the future, if the necessary facilities can be provided on an adequate scale.

The two most important articles in the report deal with the plaice and the herring. The plaice investigations were commenced in 1908 and were specially extended in 1919–21. They are now summarised for the whole period in a series of tables which include all the data. These tables will have a permanent value as a record of the condition of the plaice population, and will be invaluable for comparison with the results obtained in future years. The discussion of the data is limited to broad general features, and is directed throughout to show the bearing of the work on the actual practical problems with which the Sea Fisheries Committee is called upon to deal.

The herring work is of a more technical statistical character, and it is difficult to avoid a feeling of regret that so much work in mathematical analysis has been carried out upon samples containing for the most part only 50 fish. The work, it is true, is preliminary, and it will probably be found more profitable in the future to examine fewer samples and fewer characters but with very much larger numbers of fish.

Mention must be made of Mr. R. J. Daniel's work on the chemical composition of mussels, especially on the substance which has been called "glycogen" in these shell-fish. It is most important that these biochemical studies should be continued, for they promise results of much interest.

The report of the Marine Biological Station at Port Erin for 1922 has also been published recently. The most important paper in this report is by the late Prof. Benjamin Moore, in co-operation with Messrs. E. Whitley and T. A. Webster, on the subject of photo-synthesis in marine algæ. The authors show that green, brown, and red algæ are arranged on the shore so that each kind is in that intensity of illumination which is the optimum for the colour scheme of chromophylls it possesses. In strong illumination, green algæ synthesise far more rapidly than red, but in weak illumination the red algæ synthesise more rapidly than green. The brown algæ are intermediate in their action.

The two reports reflect credit both on those responsible for the organisation of the investigations and on those who have carried them out.

University and Educational Intelligence.

ABERDEEN.—By the bequest of the late Miss Anne Hamilton Cruickshank in 1911, a sum of money was set aside for the foundation of a chair in astronomy. The special trustees have now reported to the University Court that the accumulated sum available exceeds 15,000*l*., and have recommended the foundation of a chair, or lectureship, in astronomy, including navigation and meteorology. The recommendation is under consideration by a committee of the Court. Miss Cruickshank was the daughter of John Cruickshank, professor of mathematics in Marischal College and University from 1817 to the union of the Universities in 1860. Miss Cruickshank also founded the Botanic Gardens and the Cruickshank Law prize, while the Science Library of the University is associated with her name.

Notice is given that the Blackwell Prize Essay, value 30*l*., and open to all, will be awarded in 1924 for the best essay on "The History of the Fishing Industry of the Port of Aberdeen since 1800," provided any essay sent in is of sufficient merit. Each essay (which must bear a motto and be accompanied by a sealed envelope bearing the same motto and enclosing the name and address of the sender) must be sent to reach the Secretary of the University not later than January 1, 1924.

CAMBRIDGE.—A Bill has been presented to the House of Lords appointing Statutory Commissioners for the Universities of Oxford and Cambridge to make statutes and regulations in general accordance with the recommendations contained in the recent Report of the Royal Commission. The Cambridge Commissioners named in the Bill are Viscount Ullswater (chairman), Bishop Ryle, Sir Thomas Heath, Sir Richard Glazebrook, Sir Henry Wilson, Sir Hugh Anderson, Dr. Peter Giles, Mr. William Rendell, and Dr. Hugh Dalton. It is perhaps significant of the difference between the two Universities that the only Fellow of the Royal Society among the Oxford Commissioners is Sir Archibald Garrod, Regius professor of medicine. A few only of the provisions in the Bill can be selected for mention here. In making statutes the Commissioners are to have regard to the main design of the founder of any institution or emolument affected by the statute. In the case of a statute affecting a college they are to have regard to the maintenance of the college in the interests of education, religion, learning, or research. In particular, in prescribing the scale or basis of assessment of contributions made by the colleges to University purposes, regard is to be had in the first place to the needs of the several colleges in themselves for educational and other collegiate purposes. It is not desired in reforming Oxford and Cambridge to reform away the peculiar characteristics which have built up their present strong position in the world of education, religion, learning, and research.

Dr. G. S. Graham Smith, Pembroke College, has been appointed reader in preventive medicine; Dr. J. T. MacCurdy, Corpus Christi College (also of Toronto and Johns Hopkins Universities), has been appointed University lecturer in psychopathology; J. Mills, research student, Gonville and Caius College, has been elected to the Nita King research scholarship in the etiology, pathology, and prevention of fevers.

LONDON.—The latest date for the receipt of applications for grants from the Dixon Fund for the assistance of scientific investigations is May 14 next. Applications, accompanied by the names and addresses of two references, must be sent to the Academic Registrar, University of London, South Kensington, S.W.7.

DR. ETHEL N. MILES THOMAS, fellow of University College, London, has been appointed lecturer in botany and zoology at University College, Leicester.

THE *Times* announces that Sir Walter Buchanan, a pioneer of the frozen-meat export industry, has given 10,000*l*. for the establishment of a chair of agriculture at Victoria College, Wellington (N.Z.).

THE University of Budapest announces that summer courses will be held this year from August 1 to September 15 under its auspices. Lectures will be given by members of the faculties of theology, law, medicine, arts, and economics. Full prospectuses are in preparation.

THE Government of Western Australia has allocated a special grant this year for the commencement of the permanent buildings of the University of Western Australia, Perth. As recommended by the professorial board, the science departments will be the first to be removed to new premises, and the present grant for the period ending June 30, 1923, is for the provision of a joint building for the biology and geology departments. The next buildings to be erected will be those for chemistry and for physics. The new site for the University is at Crawley, and covers an area of about 160 acres. The science buildings will be placed on high ground adjoining the national reserve of King's Park, and their southern frontages will command a splendid view of the broad sheet of Melville Water on the Swan River.

WE notice that numerous appeals have been issued by professors in Germany for money for institutions for higher education and research, such as the Emperor William Institute for Physics, the English Seminary in Berlin University—by Prof. Alois Brandt, who advocates the compulsory teaching of English in all the higher public schools of Germany —the Cancer Research Institute, the Seminary for Christian Archæology, the Egyptian Seminary, and the High School of Jewish Studies. It is stated that a good deal of political recrimination has found its way into the appeals. Whatever may be thought of the policies of the German Government since the War in other respects, it cannot fairly be charged with failure to appreciate the vital importance of education. We have excellent authority for believing that throughout its financial difficulties Germany has had no disposition to economise in its educational expenditure. The universities, as was pointed out in these columns some months ago, were never depleted of students during the War to anything like the same extent as ours, while since the War they have been filled to overflowing; but the appeals would seem to indicate that the Government has been less generous to institutions for higher education and research than to the elementary and secondary schools and the new "People's High Schools." The depreciation of the mark has of course led to difficulties in the way of obtaining English books and periodicals, and these have been to some extent met by a system of exchange with British universities established last year by the Universities Bureau.

THE twenty-first annual meeting of the Carnegie Trust for the Universities of Scotland was held on February 14, Lord Sands presiding. The original endowment fund of 2,000,000*l*. has been increased by 547,000*l*., in addition to which there are reserve funds amounting to nearly 183,000*l*. Expenditure for the year ended September 30, 1922, amounted to 125,292*l*., including: assistance in payment of class-fees, 61,217*l*.; grants to universities and colleges for buildings, lectureships, libraries, etc., 44,925*l*.; encouragement of post-graduate study and research, 17,063*l*.; annual grant to women students' union, 250*l*.; management expenses, 5193*l*. Post-graduate study and research were encouraged by fellowships, scholarships, and prizes (6958*l*.), grants towards salaries of part-time research assistants (3600*l*.), grants to the Laboratory of the R.C.P., Edinburgh (2740*l*.), to St. Andrews Institute for Clinical Research (1000*l*.), and other grants (2765*l*.). Arrangements were made with the Department of Scientific and Industrial Research for the simultaneous consideration of applications. During the year sums amounting to 1387*l*. were voluntarily repaid by or on behalf of 39 beneficiaries, making a total of 12,583*l*. repaid since 1901. The repayments by women exceeded those by men for the first time both in number and total amount. In the annual report of the Carnegie Corporation of New York, issued a few days earlier than the Scottish report, stress is laid on the dangers and difficulties incidental to the administration of all such charitable foundations and the necessity for the exercise of careful discrimination and constant watchfulness for the harmful as well as the beneficial results of giving. Among the former it mentions the overcrowding of the colleges with students, many of whom would find their greatest happiness in other vocations than those to be sought through college training.

Societies and Academies.

LONDON.

Zoological Society, March 20.—Prof. E. W. MacBride, vice-president, in the chair.—S. Ch. **Sarkar**: A comparative study of the buccal glands and teeth of opisthoglyph snakes, and a discussion on the evolution of the order from Aglypha.—Oldfield **Thomas** and M. A. C. **Hinton**: On the mammals obtained in Darfur by the Lynes-Lowe expedition.—R. I. **Pocock**: (1) On the external characters of Elaphus, Hydropotes, Pudu, and other Cervidæ. (2) The classification of the Sciuridæ.

The Optical Society, March 22.—Instr.-Commander T. Y. Baker in the chair.—Dr. L. C. **Martin**: Surveying and navigational instruments from a historical standpoint. Before A.D. 150 accurate knowledge of the Mediterranean basin was obtained by Ptolemy. One of the best known of the early instruments was the astrolabe, and this instrument was developed considerably by the Arabs and others. Specialised forms were used for navigation. In the seventeenth century a simplified form of the astrolabe, capable of being suspended or mounted horizontally on a stand, was employed as a theodolite. This was subsequent to the description of Digges's *theodolitus*, in which independent horizontal and vertical axes were employed. The use of the telescopic sight was not applied to surveying instruments till the beginning of the eighteenth century. The history of the level, from the "open sight and gravity controlled" forms to the telescopic levels of Picard and the bubbles of Thévenot, was also discussed. Improvements by various artists in the methods of graduation of circles and the development of dividing engines from Hindley to Ramsden and Troughton were matters of the greatest moment in the development of modern instruments. Later developments were shown in the instruments by Troughton and by Cary, which brought the level of construction (from the purely scientific point of view) almost up to that of our own time.

CAMBRIDGE.

Philosophical Society, March 5.—Mr. C. T. Heycock, president, in the chair.—Sir Ernest **Rutherford**: The capture and loss of electrons by α-particles. In a recent paper (Proc. Roy. Soc. A, 102, p. 497, 1922) G. H. Henderson showed that swift α-particles can capture electrons and are thus converted into singly charged and neutral helium atoms. The magnetic deflexion of a pencil of α-rays in a high vacuum showed by the photographic method after passing through mica the presence of two bands—one, the main band, due to He^{++}, and the other, the midway band, due to He^{+} particles. The relative number of the latter increased rapidly with reduction of velocity of the α-rays. These conclusions have been confirmed by the scintillation method. By deflecting the midway band by a combined electric and magnetic field, it has been proved that it is due to He^{+} particles. For any velocity there is a temporary equilibrium between the number of He^{++} and He^{+} particles, such that the number of captures is equal to the number of losses. The ratio of the numbers of singly and doubly charged particles between the velocities $7\cdot7 \times 10^8$ and 18×10^8 cm. per second, varies approximately as the inverse fifth power of the velocity. The disappearance of the midway band when gas at low pressure is introduced in the path of the rays gives a method of determining the mean free path of the He^{+} particles in air and other gases before conversion into He^{++}. The mean free path varies roughly as the velocity of the α-rays, and is 4 to 5 times longer in hydrogen and helium than in air. The mean free path for capture varies roughly as the inverse sixth power of the velocity. The mean free path in air for a velocity $1\cdot5 \times 10^9$ cm. per sec. is about 0·56 mm. at N.T.P. for capture and 0·008 mm. for loss. The average α-particle captures and loses an electron many hundred times before it is absorbed.—P. **Kapitza**: Some observations on α-particle tracks in a magnetic field.—H. **Lamb**: The magnetic field of a helix.—W. **Burnside**: (1) The theory of errors of observation; (2) The solution of a certain partial difference equation.—P. M. S. **Blackett**: A note on the natural curvature of α-ray tracks. An apparent relation exists between the plane and direction of the curvature of the parts of a forked track and the plane and type of the fork itself. The natural curvature possibly involves the effect on the ionisation of the probable assymmetric structure of singly charged α-particles.

SHEFFIELD.

Society of Glass Technology (Birmingham meeting), March 21.—Prof. W. E. S. Turner in the chair.—H. S. **Blackmore**, Violet **Dimbleby**, and W. E. S. **Turner**: A rapid method of testing the durability of glassware. When a very dilute solution of 1 part in 1000 of the alkaloid, narcotine hydrochloride, is heated to boiling-point inside a glass vessel, the alkaloid is thrown out of solution, and can be seen as a fine precipitate if the glass is of poor quality. Good glasses should show no sign of deposit when heated at the boiling-point for an hour.—D. **Turner** and W. E. S. **Turner**: The corrosion of fireclay refractory material by glass and glass-making materials.—Edith M. **Firth**, F. W. **Hodkin**, and W. E. S. **Turner**: The effect of saltcake in corroding fireclay materials. Both papers were presented by Prof. Turner. Experimental evidence was detailed, showing that in glass-melting the corrosion of the pots or the tank blocks is most severe during the early stages of the melting of the batch; sodium nitrate, potassium nitrate, and borax are particularly corrosive. As the proportion of saltcake used in the batch increased, so did the extensiveness of the corrosion. Resistance to corrosion can be improved by firing the pots and blocks at 1400° C. before the charge of batch was inserted.

PARIS.

Academy of Sciences, March 19.—M. Albin Haller in the chair.—The president announced the death of M. Van der Waals, foreign associate.—Emile **Borel**: The approximation of rational or incommensurable numbers belonging to given enumerable ensembles.—L. **Lecornu**: The time of revolution of the planets. A discussion of a question raised in a recent note by M. Jean Chazy.—Charles **Moureu** and Charles **Dufraisse**: Auto-oxidation and anti-oxygenic action. The catalytic properties of iodine and its compounds. The case of acrolein. According to the theory of the mechanism of anti-oxygenising action developed by the authors, iodine and its compounds should exert catalytic properties in phenomena of auto-oxidation, and should, under certain conditions, possess the anti-oxygenising property. Iodides of various metals and organic bases (33 in all) were shown to inhibit the oxidation of acrolein at a concentration of 1 in 1000.—L. **Maquenne**: The hydrolysis of maltose by malt extract.—G. **Gouy**: The improvement of the microscope by the use of X-rays.—C. **Guichard**: Triply indeterminate systems of spheres, circles, and double points.—Jules **Andrade**: An arrangement of four regulating springs producing a constant friction and a quadratic friction.—J. B. **Senderens**: The catalytic dehydration of alcohols by dilute sulphuric acid. Both the ether and substituted ethylene can be prepared by the action of sulphuric acid on the corresponding alcohol, and the ratio of ether (alkyl oxide) to ethylene can be varied by the addition of water to the acid.—Ph. **Glangeaud**: A trial boring for petroleum at Crouelle, near Clermont-Ferrand (Puy-de-Dôme). The boring was taken down to 856 metres, and full details of the strata met with are given. At 596 metres there was a strong evolution of inflammable gas and about a ton of a heavy oil was collected (density 0·963, sulphur 9·3 per cent.). More oil, in smaller quantities, was obtained at greater depths. The tube was broken by an accident at 787 metres.—M. Emanuele **Paterno** was elected foreign associate, in succession to the late Prince of Monaco.—Georges **Bouligand**: Some points in functional analysis.—W. **Margoulis**: The general theory of the representation of equations by means of mobile elements.—J. **Haag**: The problem of *n* bodies in relativity.—Henry **Hubert**: A method, considered as new, for the stereoscopic representation of topographical surfaces.—R. **Dufour**: High frequency induction furnaces.—A. **Leduc**: A new improvement of the equation of state of gases.—Léon and Eugène **Bloch**: Spark spectra of higher order. A study of the spectrum of mercury obtained by the oscillating discharge in a silica tube without electrodes. The appearance and number of lines change as the voltage increases.—C. E. **Guye**: The kinetic interpretation of the rule of van't Hoff.—Réne **Audubert**: The action of gelatin upon concentration cells. A study of the effect of the progressive addition of gelatin on the E.M.F. of the concentration cells AgI—$AgNO_3$; AgCl—$AgNO_3$; Ag_2S—$AgNO_3$. The results appear to show that the Ag ion is adsorbed by the gelatin.—L. **Bert**: A new synthesis of cumene and *p*-cymene. Isopropyl sulphate reacts with C_6H_5MgBr giving cumene: the magnesium derivative of *p*-bromotoluene with isopropyl sulphate reacts similarly, giving *p*-cymene.—Emile **André**: The acid-alcohols contained in the oil from grape stones.—Henry **Joly**: Some peculiarities of the Bajocian in the neighbourhood of Montmédy (Meuse).—Ch. **Maurain**: Magnetic measurements in Brittany. The results of observations made at forty-one stations in August and September 1922, and the magnetic elements (declination, inclination, and horizontal component) reduced to January 1, 1922.—Filippo **Eredia**: The temperature of the air in the province of Tripoli.—L. **Blaringhem**: New facts relating to the hybrids of wheat and Ægilops.—H. **Colin** and Mlle. Y. **Trouard-Riolle**: Dissociation of the hybrid: smooth-bearded black barley and Albert barley.—Lucien **Daniel**: Regeneration of the potato by grafting. An account of attempts to increase the resistance to disease of the potato by grafting on tomato. The experiments have given promising results.—A. **Polack**: The accommodative compensation of the chromatism of the eye. Insufficiency of d'Alembert's theory.—L. **Garrelon** and D. **Santenoise**: Relations between the resistance of the organism to poisons and the rapid modification of the oculo-cardiac reflex. Contribution to anti-anaphylaxy.—Marc **Romieu**: Contribution to the comparative histology of striated muscle.—Mme. J. Samuel **Lattès**: The physical conditions which accompany the phenomenon of necrosis produced by radium radiation.

Official Publications Received.

Report of the Rugby School Natural History Society for the Year 1922. Pp. 52. (Rugby.)

The National University of Ireland. Calendar for the Year 1922. Pp. viii+323+334+86. (Dublin.)

Annals of the Transvaal Museum. Vol. 9, Part 3: The Sphegidæ of South Africa. By Dr. George Arnold. Part 2. Pp. 143-190. Vol. 9, Part 4: The Sphegidæ of South Africa. By Dr. George Arnold. Part 3. Pp. 191-253. (Cambridge: Printed at the University Press.)

Stonyhurst College Observatory. Results of Geophysical and Solar Observations, 1922. With Report and Notes of the Director, Rev. A. L. Cortie. Pp. xv+43. (Blackburn.)

Annuaire de l'Observatoire Royal de Belgique, 1924. Pp. vi+550. (Bruxelles: M. Hayez.)

Diary of Societies.

MONDAY, April 16.

Royal Geographical Society (at Lowther Lodge, Kensington Gore), at 5.—W. Irwin: The Salts of the Dead Sea and River Jordan.

Royal College of Surgeons of England, at 5.—Prof. Shattock: Demonstration of Specimens Illustrating Repairs of Fractures.

British Psychological Society (Industrial Section) (at University College), at 6.—Dr. G. H. Miles: Rest Pauses.

Royal Society of Arts, at 8.—E. Kilburn Scott: The Fixation of Nitrogen (2). (Cantor Lecture.)

Chemical Industry Club (at 2 Whitehall Court), at 8.

TUESDAY, April 17.

Royal Institution of Great Britain, at 3.—Sir Arthur Keith: The Machinery of Human Evolution (2). How Old Structures are Lost.

Royal Society of Medicine, at 5.—General Meeting.

Royal Statistical Society, at 5.15.—Dr. E. C. Snow: Trade Forecasting and Prices.

Royal Society of Medicine (Orthopædics Section), at 5.30.

Institution of Civil Engineers, at 6.—Special General Meeting.

Institute of Marine Engineers, Inc., at 6.30.—R. Clark: The Operation of Water-tube Boilers for Cargo-Passenger Ships.

Royal Photographic Society of Great Britain, at 7.—J. C. Dollman: Difficulties in Painting and Photography.

Royal Anthropological Institute, at 8.15.—Miss Tyra de Kleen: The Ceremonial Dances and Magic Rites of the Island of Bali, Dutch East India.

WEDNESDAY, April 18.

Royal Meteorological Society, at 5.—W. H. Dines and L. H. G. Dines: An Examination of British Upper Air Data in the Light of the Norwegian Theory of the Structure of the Cyclone.—Tatuo Kobayasi: The Mechanism of Cyclones and Anti-cyclones.—Capt. E. C. Shankland: Notes on the Fluctuations of Mean-sea-level in Relation to Change of Atmospheric Pressure, from Observations at Liverpool, August and September 1920.

Geological Society of London, at 5.30.—J. F. N. Green: The Structure of the Bowmore-Portaskaig District of Islay.

Royal Microscopical Society, at 8.—D. W. Cutler: The Protozoa of the Soil.—Prof. A. C. Seward: The Use of the Microscope in Palæobotanical Research.

THURSDAY, April 19.

Royal Institution of Great Britain, at 3.—Prof. A. O. Rankine: The Transmission of Speech by Light (2).

Linnean Society of London, at 5.—E. Heron-Allen and A. Earland: The Foraminifera of Lord Howe Island, South Pacific.—The General Secretary: The History of Botanic Illustration in Colour during Four Centuries.

Institution of Mining and Metallurgy (at Geological Society of London), at 5.30.

Society for Constructive Birth Control and Racial Progress (at Essex Hall, Strand), at 8.—C. E. Pell: Is the Fall in the Birth-rate a Natural Law?

Chemical Society, at 8.—R. Ibbotson and J. Kenner: The Influence of Nitro-groups on the Reactivity of Substituents in the Benzene Nucleus. Part VII. Reactions of 2:5- and 4:5-dinitro-*m*-xylene.—S. F. Birch, G. A. R. Kon, and W. S. G. P. Norris: The Chemistry of the Three Carbon System. Part I. The Influence of the *Cyclo*hexane Ring on the $\alpha\beta$-$\beta\gamma$ Change.—S. Medsforth: The Promotion of Catalytic Reactions. Part I.

FRIDAY, April 20.

Royal Society of Arts (Dominions and Colonies and Indian Sections), at 4.30.—Sir Richard A. S. Redmayne: The Base Metal Resources of the British Empire.

Royal College of Surgeons of England, at 5.—Sir Arthur Keith: The Shape and Relationships of the Stomach.

Institution of Mechanical Engineers, at 6.

Junior Institution of Engineers, at 7.30.—H. H. Munro: The Business of Engineering.

Institution of Engineering Inspection (at Royal Society of Arts), at 7.30.—C. H. Richardson: The Inspection of Ball Bearings.

Royal Photographic Society of Great Britain, at 8.—J. Sewell: The Commercial Aspects of Pictorial Photography.

Royal Society of Medicine (Anæsthetics Section) (Annual General Meeting and an Ordinary Meeting), at 8.30.—Dr. J. H. Chaldecott and others: Discussion on Coroners' Inquests: the Classification of Anæsthetic Deaths as violent or unnatural.

Royal Society of Medicine (Electro-Therapeutics Section), at 8.30.—Dr. R. W. A. Salmond: A case illustrating the value of Pneumopericardium.

Royal Institution of Great Britain, at 9.—Dr. W. J. S. Lockyer: The Growth of the Telescope.

The Interior of a Star.[1]

By Prof. A. S. Eddington, F.R.S.

On December 13, 1920, the angular diameter of a star was measured for the first time in history with an apparatus devised by Prof. A. A. Michelson. Hitherto every star had appeared as a mere point of light, and no test had been able to differentiate it from a geometrical point. But on that eventful evening a 20-foot interferometer constructed at the Mt. Wilson Observatory was turned on the star Betelgeuse, and the measurement revealed that this star had a disc $\frac{1}{20}$ of a second of arc in diameter—about the size of a halfpenny 50 miles away. The distance of Betelgeuse is known roughly (unfortunately it cannot be found so accurately as the distances of many stars), so that we can convert this apparent size into approximate actual size. Betelgeuse is not less than 200 million miles in diameter. The orbit of the earth could be placed entirely inside it.

The stars are thus not limited to objects of comparatively small bulk like the sun; there are among them individuals truly gigantic in comparison. We can add another step to the astronomical multiplication table—a million earths make one sun; ten million suns make one Betelgeuse. This is a comparison of volume, not of amount of material. It leaves open the question whether, in order to obtain one of these giants, we should take the material of ten million suns rolled into one, or whether we should take the material of the sun and inflate it to ten million times its present size. There is no doubt that the latter answer is nearer the truth. Betelgeuse, I admit, contains more matter than the sun (perhaps 50 times as much); but in the main its vast bulk is due to the diffuseness with which this material is spread out. It is a great balloon of low density, much more tenuous than air, whereas in the sun the material is compressed to a density greater than water.

Whether the star is one of these balloon-like bodies or whether it is dense like the sun depends on the stage of its life at which we catch it. It is natural to think that the stars gradually condense out of diffuse material, so that they become denser and denser as their life-history proceeds. We can now see in the heavens samples of every stage in the development of a star. The majority of those seen with the naked eye are in the early diffuse state; that is not because these young stars are really more numerous, but because their great bulk renders them brighter and more conspicuous. What I shall have to say about the inside of a star refers chiefly to the young diffuse stars—the *giant stars* as they are called. The reason is that we understand much more about the properties of matter when it is in the condition of a perfect gas than when it is condensed; although the difficulties of treating a dense star like the sun are not insuperable, we have naturally made the most progress with the easier problem of giant stars.

[1] Discourse delivered at the Royal Institution on February 23.

Internal Temperatures.

We only observe the physical conditions at the surface of a star, and at first it might seem impossible to learn anything about the conditions in the interior. Consider, for example, the question of temperature. The nature of the light received from Betelgeuse teaches us that the temperature is 3000° C.—not an extravagantly high temperature judged even by terrestrial standards. But this refers, of course, to the layer near the surface from which the observed light is coming; it is just the marginal temperature of the furnace affording no idea of the terrific heat within. I shall not attempt to explain in detail how we manage to calculate the inside temperatures; but I can perhaps show that there is a clue which can be followed up by appropriate mathematical methods.

Elasticity is a well-known property of a gas, familiar to everybody through its practical application in the pneumatic tyre. What gives the gas its elasticity or expansive force is its heat, that is to say, the energy of motion of its molecules hastening in all directions and continually tending to spread apart. The greater the heat the greater the expansive force. Now at any point inside the star a certain condition of balance must be reached; on one hand we have the weight of all the layers above pressing down and trying to squeeze closer the gas inside; on the other hand we have the elasticity of this inside gas trying to expand and force the upper layers outwards. Since neither one thing nor the other happens and the star remains practically unchanged for hundreds of years, we must conclude that these two tendencies just balance. At each point the elasticity and therefore the heat has to be of the exact amount needed to bear the weight of the layers above. That is the principal clue by which we determine how much heat there must be at various depths inside the star.

The internal temperature depends on the particular star considered, but it is generally from 2 to 20 million degrees at the centre. Do not imagine that this is a degree of heat so vast that ordinary conceptions of temperature have broken down. These temperatures are to be taken quite literally. Temperature is a mode of describing the speed of motion of the ultimate particles of the matter. In a mass of helium at ordinary temperatures the average speed of the atoms is rather less than 1 mile per second; at 4 million degrees it is 100 miles per second. This is a high speed, but not a speed to feel uncomfortable over. Sir Ernest Rutherford describes atoms of helium moving at the rate of 100,000 miles a second. I cannot vie with him. I usually find that my physical colleagues are rather disappointed with our jog-trot atoms in the stars.

Material and Ætherial Heat.

We must imagine then a typical giant star as a mass of material with average density about that of air swollen to at least a thousand times the bulk of the sun. The atoms of which it consists are rushing in all directions with speeds up to 100 miles a second, continually colliding and changing their courses. Each atom is being continually pulled inwards by the gravitation of the whole mass, and as continually boosted out again by collision with atoms below. The energy of this atomic motion constitutes a great store of heat contained in the star; but this is only part of the store. The star contains a store of another kind of heat—ætherial heat, or æther-waves like those which bring to us the sun's heat across 90 million miles of vacant space. These waves also are hastening in all directions inside the star. They are encaged by the material, which prevents them leaking into outer space except at a slow rate. An æther-wave making for freedom is caught and absorbed by an atom, flung out in a new direction, and passed from atom to atom; it may thread the maze for hundreds of years until by accident it finds itself at the star's surface, free now to travel through space indefinitely, or until it ultimately reaches some distant world, and perchance entering the eye of an astronomer, makes known to him that a star is shining.

The possession of this double store of heat is a condition which we do not encounter in any of the hot bodies more familiar to us. It is a new phase of matter beyond the reach of laboratory experiment, although happily the theory is so simple that there cannot be much uncertainty as to behaviour. It is true that a red-hot mass of iron contains a little of this ætherial heat in addition to the heat comprised in the motion of its molecules, but it is less than a billionth part of the whole. Only in the giant stars does the ætherial portion rise to importance. A red-hot metal emits ætherial heat, but it keeps no appreciable store; it converts the material heat into this form as it is required for use. The star rejects this hand-to-mouth method; and although it is continually changing elements of heat from one form to the other, it keeps a thousand years' supply always in readiness and emits its radiation by leaking ætherial heat from the store. In older theories this feature was not realised; it was supposed that convection currents must exist continually bringing up hot matter from the interior to replace the surface-matter which had radiated and cooled. Now it is seen that the difficulty is rather in the other direction—how does the star dam back the store of æther-waves so that they do not escape from it faster than we observe? This change of view has necessitated modifications of the older theories of Lane and others, and has on the whole considerably simplified the problem.

In the hot bodies of the laboratory the heat is almost entirely in the material form, the ætherial portion being insignificant. In the giant stars the heat is divided between the two forms in roughly equal amounts. Can we not imagine a third condition in which this time the heat is almost wholly ætherial, the material portion being insignificant? We can imagine it, no doubt; but the interesting, and I believe significant, thing is that we do not find it in Nature.

Light Pressure.

You have heard of the pressure of light—that light actually has mass and weight and momentum and exerts a minute pressure on any object which obstructs it. A beam of light or æther-waves is like a wind, a very minute wind as a rule; but the intense ætherial energy inside the star makes a strong wind. This wind distends the star. It bears to some extent the weight of the layers overhead, leaving less for the elasticity of the gas to bear. That, of course, has to be taken into account in our calculation of the internal temperatures—making them lower than the older theory supposed. Just as æther and matter share the heat-energy between them, so the ætherial wind and the material elasticity share the burden of supporting the weight of the layers above. We are able to calculate the proportions in which they share it. To a first approximation the same proportion holds throughout nearly the whole interior, and the proportion depends only on the total mass of the star—not on the density or even on the chemical composition of the material. Moreover, in order to make this calculation we do not need any astronomical knowledge; all the constants in the formula have been determined by the physicist in his laboratory. We need to know the average molecular weight of the material, but I shall tell you later how we are able to fix that approximately in spite of not knowing what elements to expect in the star's interior; that happens to be one of the benefits of dealing with very high temperatures.

Let us imagine a physicist on a cloud-bound planet, who has never heard tell of the stars, setting to work to make these calculations for globes of gas of various dimensions. Let him start with a globe containing 10 grams, then 100 grams, 1000 grams, and so on, so that his nth globe contains 10^n grams. They mount up in size rather rapidly. No. 1 is about the weight of a letter; No. 5, a man; No. 8, an airship; No. 10, an ocean liner; after that comparisons are difficult to find. The following table gives part of his results:

No. of Globe.	Ætherial Pressure.	Material Pressure.
30	0·00000016	0·99999984
31	0·000016	0·999984
32	0·0016	0·9984
33	0·106	0·894
34	0·570	0·430
35	0·850	0·150
36	0·951	0·049
37	0·984	0·016
38	0·9951	0·0049
39	0·9984	0·0016
40	0·99951	0·00049

It is obvious why I omit the rest of the table; it consists of long strings of 0's and 9's. But for the 33rd, 34th, and 35th globes the table becomes interesting; and then lapses back into 9's and 0's again. Regarded as a tussle between æther and matter to control the situation, the contest is too one-sided to be interesting, except just from Nos. 33 to 35, where something more exciting may be expected.

Now let us draw aside the veil of cloud behind which our physicist has been working and let him look up into the skies. He will find there a thousand million globes of gas all of mass between the 33rd and 35th globes. The lightest known star comes just below the 33rd globe; the heaviest known star is just beyond the 35th globe. The vast majority are between Nos. 33 and 34, just where the ætherial pressure begins to be an important factor in the situation.

It is a remarkable fact that the matter of the universe has aggregated primarily into units of nearly constant mass. The stars differ from one another in brightness, density, temperature, etc., very widely; but they all contain, roughly, the same amount of material. With a few exceptions they range from ½ to 5 times the mass of the sun. I think we can no longer be in serious doubt as to the general cause of this, although the details of the explanation may be difficult. Gravitation is the force which condenses matter; it would if unresisted draw more and more matter together, building globes of enormous size. Against this, ætherial pressure is the main disruptive force (doubtless assisted by the centrifugal force of the star's rotation); its function is to prevent the accumulation of large masses. But this resistance, as we see, only begins to be serious when the mass has already nearly reached the 33rd globe; and if indeed it is efficacious, it will stop the accumulation before the 35th globe is reached, because by then it has practically completely ousted its more passive partner (material pressure). We do not need to know exactly how strong the resistance must be in order to prevent the accumulation, because, when once the resistance begins to be appreciable, it increases very rapidly and will very soon reach whatever value is required. All over the universe the masses of the stars bear witness that the gravitational aggregation proceeded just to the point at which the opposing force was called into play and became too strong for it.

Ascending and Descending Temperature Stages.

It was shown by Homer Lane in 1870 that as a gaseous star contracts its temperature will rise. Betelgeuse is typical of the first stage when the temperature has risen just far enough for the star to be luminous. It will go on contracting and becoming hotter, its light changing from red to yellow and then to white. But evidently this cannot go on indefinitely. When the condensation has proceeded far enough the material will be too dense to follow the laws of a perfect gas. A different law then begins to take control. The rise of temperature becomes less rapid, is checked, and finally the temperature falls. We can calculate that the greatest temperature is reached at a density of about ¼ to ⅓ that of water. The sun is denser than water, so that it has passed the summit and is in the stage of falling temperature. So long as the temperature is rising the brightness of the star scarcely changes. It is becoming hotter, but smaller. Calculation shows that the increased output of light and heat per square metre of surface, and the decreased area of the surface, very nearly counteract one another, so that the total output remains fairly steady. But on the downward path the falling temperature and diminishing surface both reduce the light, which falls off rapidly between the successive stages or types which we recognise. That is entirely in accordance with what is observed to happen.

Taking any level of temperature, a star will pass through it twice, once ascending and once descending. In the main we have been in the habit of classifying stars according to their surface temperature, because it is on this that the spectral characteristics of the light, its colour, and the chemical elements revealed, chiefly depend. But that classification mixes together stars from an early ascending stage and from a later descending stage. For example, a star like Betelgeuse just beginning its career is put in the same class with a dense red star which has run its course and reached its second childhood. They are both red stars of low temperature, and that was good enough for the early attempts at classification. Sir Norman Lockyer always stoutly maintained the existence of the ascending and descending series; but he was almost alone among spectroscopists in this. He did not actually succeed in separating the ascending and descending stars though sometimes he came very near to the right criterion. We owe to Russell and Hertzsprung the actual separation. They discovered it not by spectroscopy, but by measuring the absolute brightness of stars; the greater brightness of the ascending stars, due to their large bulk, easily distinguishes them from the descending stars, at any rate in the low-temperature groups. At the highest temperatures the two series merge into one another.

The disentangling of the two series, and the recognition of the true sequence of stellar evolution, is probably the most revolutionary and far-reaching of recent discoveries in stellar physics. It began to oust the older view about 1914, and it is worth noticing that the discovery was made from observations coming under the province of the older astronomy and not what is generally called astrophysics. The data were parallaxes, proper motions, double star orbits, etc. The spectroscopists had been misled as to the order of evolution, and it was left to the rival branch of astronomy to show the way; but they were not to be outdone for long. Adams and Kohlschütter have found an easy spectroscopic method for distinguishing the ascending and descending stars. Although our main purpose now is to grope in the interior of a star, perhaps we may emerge at the surface for a moment to consider what is the difference of surface condition of a diffuse and condensed star, respectively, which enables the spectroscope to distinguish between them.

Surface Conditions.

The state of the outermost layers of a star can, it would seem, be influenced by two factors only, (1) the intensity of the stream of radiant energy crossing through them and (2) the intensity of gravitational attraction holding them to the star. The former is measured by the effective temperature, so that we have the two variable factors, temperature and gravity. The spectrum presumably will vary as the conditions governed by these factors vary. We must not expect to be able to classify the spectra accurately in a single sequence; they can vary in two directions. The ordinary classification depends principally on the temperature factor; we may call this the longitudinal sequence. Adams's new method aims at disentangling the transverse sequence corresponding principally to the gravity factor. We may say that his method is really a way of finding the value of gravity at the surface of a star, although it is not yet possible to put the value into actual numbers. Clearly, gravity will be smaller in the diffuse stage than in the dense stage on account of the greater distance from the centre to the surface.

The effect of lowering gravity is to make the density smaller at corresponding temperature. This introduces an important change in the state of the gas, namely, ionisation. At moderately high temperatures the atoms begin to lose one or more of their most loosely attached electrons, a process called ionisation. Ionisation is facilitated by low density and prevented by high density. The theory of ionisation in stellar atmospheres has been chiefly worked out by M. N. Saha, who has arrived at many interesting results. Here we need only remark that the ionised atoms give rise to different spectra, which have long been distinguished from the spectra of the neutral atoms. The lower density in the atmosphere of diffuse stars should strengthen the "enhanced" lines due to ionised atoms, compared with the "arc" lines due to neutral atoms. The difference in general is not very large, but the atoms of certain elements for which the conditions are most critical, are specially sensitive to the change of density. This is the criterion which Adams and Kohlschütter found empirically, and it distinguishes quite easily the ascending and descending series. To a limited extent it also distinguishes the larger and smaller stars within the same series.

Although the stars begin to shine on reaching a temperature of about 3000° and return to this temperature at the close of their luminous existence, they do not all climb the temperature-ladder to the same height. The more massive stars climb higher than the light stars. We can to some extent calculate the height to which they will go; but I am afraid the figures at present are very uncertain, though there is hope of improving them before long. The sun's surface temperature is now about 5900°; I do not think that it ever went higher than 6600°; it had not sufficient mass to go beyond. Sirius, nearly 2½ times as massive as the sun, has climbed to 11,000°, and at the moment is practically at its maximum, having only just turned downward. Still hotter stars like Rigel are known, and these must be more massive still. At the other end of the scale a star of mass less than 1/7 of the sun would not be able to reach 3000°, and could scarcely be luminous; but in any case such small masses would be formed very seldom, for the reason explained earlier in this lecture. It is a well-known fact that hot stars on the average are more massive than cool stars; we see that this is accounted for by the smaller stars being weeded out as the temperature-standard is raised.

Atoms and Electrons.

We have hitherto pictured the inside of a star as a hurly-burly of atoms and æther-waves. We must now introduce a third population to join in the dance. There are vast numbers of free electrons—unattached units of negative electricity. More numerous than the atoms, the electrons dash about with a hundred-fold higher velocity—corresponding to their small mass, which is only 1/1850 of a hydrogen atom. These electrons have come out of the atoms, having broken loose at the high temperature here involved. An atom has been compared to a miniature solar system; a composite central nucleus carrying positive charge corresponds to the sun, and round it revolve in circular and elliptic orbits a number of negative electrons at comparatively large distances corresponding to the planets. We know the number of satellite electrons for each element; sodium has 11, iron 26, tin 50, uranium 92. Our own solar system with 8 revolving planets represents an atom of oxygen. The thermodynamical theory due mainly to Nernst permits us to calculate roughly how many of these break loose under given conditions of temperature and density; and in a typical star a large proportion of them must have become free.

This condition solves for us our chief difficulty as to the molecular weight of stellar material. We need to know it in order to perform our calculations as to the state of the star; and at first sight it might seem hopeless to arrive at the molecular weight without knowing the elements which constitute the bulk of the material. But suppose first that the temperature is so high that all the satellite electrons have broken away. An atom of sodium will have separated into 12 particles, namely, 11 electrons and 1 mutilated atom; its atomic weight 23 is divided between 12 independent particles, so that the average weight of each is 23/12=1·92. Next take iron: the atomic weight 56 is divided between 27 particles; average 2·07. For tin we have 119 divided by 51; average 2·34. For uranium, 238 divided by 93; average 2·56. It scarcely matters what element we take; the average weight of the ultimate particles (which is what we mean by the molecular weight) is always somewhere about 2. If only the stars were a bit hotter than they actually are, it would make our task very easy. Unfortunately, they are not hot enough to give complete separation, and the actual degree of separation will depend on the temperature of the star, thus introducing a difficult complication. Generally at least half the electrons are detached and the molecular weight must be taken as between 3 and 4. I hope that the theory of this dissociation of electrons will be improved, because at present it is the chief bar to rapid progress with the theory of stellar constitution. It is a great help to know that the molecular weight is between 3 and 4; but we have reached a stage when it is becoming necessary for progress to know it for each star within much closer limits.

Brightness and Mass.

We pictured a physicist on a cloud-bound planet who was able from laboratory data to predict how large would be the masses into which the material of the universe must aggregate. Let us now set him a harder task. We inform him that we have observed these masses of gas, and, choosing one equal, say, to his 34th sphere, we ask him to predict how brightly it will shine. I have already mentioned that the star keeps practically the same brightness so long as it is a perfect gas ascending in temperature, so it should not be necessary to give the physicist any data except the precise mass. To use the same plan as before, we imagine a series of lamps of 10 candle-power, 100 candle-power, 1000, and so on; and his task is to pick out which lamp in this series corresponds approximately to the star. I believe that it is now possible for him to perform this task and to pick out (correctly) the 31st lamp. But for this purpose it is not enough that he should know all about the heat stored in the interior of the star; the brightness of the star depends on the rate at which the æther-waves are leaking out, and that introduces a new subject—the obstructive power of the material atoms which dam back the radiant flow.

Another name for this obstructive power is *opacity*. A substance which strongly obstructs the passage of light and heat waves is said to be opaque. The rising temperature towards the centre of the star urges the heat to flow outwards to the lower temperature level; the opacity of the material hinders this flow. The struggle between these two factors decides how much light and heat will flow out. We have calculated the internal temperature-distribution, so that we know all about the first factor; if then we can observe the outward flow which occurs, that should settle the value of the second factor—the opacity. The outward flow is capable of observation because it constitutes the heat and light sent to us by the star.

One of the troubles of astronomy is that our information about the stars is so scattered. We know the mass of one star very accurately, but we do not know its absolute brightness; we know the brightness of another but not its mass; for a third we may have an accurate knowledge of the density but nothing else. For Sirius, Procyon, and α Centauri our knowledge is fairly complete and accurate; but not any of these are giant stars in the state of a perfect gas, and they are therefore useless for the present discussion. But within the last year we have been fortunate enough to obtain complete and very accurate information for one of the giant stars, Capella. This is another of the benefits which astronomy has derived from Prof. Michelson's interferometer method of observation. The brighter component of Capella (which is a double star) has a mass 4·2 times that of the sun and a luminosity 160 times greater. We can use these facts to calculate the opacity of Capella in the way I have described; it turns out to be 150 in C.G.S. units. To illustrate the meaning of this, let us enter Capella and find a region where the density is that of the terrestrial atmosphere we are accustomed to; a slab of this gas only 6 inches thick would form an almost opaque screen. Only $\frac{1}{20}$ of the radiant energy falling on one side would get through to the other, the rest being absorbed by the gas.

Absorption of X-rays in Stars.

It seems at first surprising that 6 inches of gas could stop the æther-waves so effectively; but we might have anticipated something like this from general physical knowledge. We give different names to æther-waves according to their wave-length. The longest are the Hertzian waves used in wireless telegraphy; then come the invisible heat-waves; then light-waves; then photographic or ultra-violet waves. Beyond these we have X-rays, and finally—the shortest of all—the γ-rays which are emitted by radioactive substances.

Where in this series are we to place the æther-waves in the interior of a star? It is solely a question of temperature, and the æther-waves at stellar temperatures are those which we call X-rays—more precisely, they are very "soft" X-rays. Now X-rays, and soft X-rays especially, are strongly absorbed by all substances. The opacity which we have found in Capella is of the same order of magnitude as the opacity of terrestrial substances to X-rays measured in the laboratory. The following table shows a few of the laboratory results compared with the astronomical value for Capella:

Wave-length (Å).	Absorption-coefficient (opacity) in			
	Aluminium.	Iron.	Silver.	Capella.
0·5	2	14	10	...
0·95	11	80	72	...
1·1	21	125	86	...
1·3	31	205	152	...
2·3	136	...	...	...
10	...	...	...	150

We have been performing an investigation of the absorption of X-rays in a star, parallel to investigations on the same subject made in the laboratory. In one respect the physicist has a big advantage because he can vary the material experimented on, whereas we have to be content with the material, whatever it is, composing the stars. But, as you see from the table, the physicist is also interested in finding how the absorption changes for different wave-lengths. We can follow him in this, and even do better than him, because he is restricted by certain practical difficulties to a narrow range of wave-length, whereas we can explore a range of wave-length covering a ratio of at least 10 to 1, by using stars of different temperatures. It is true that our results are not yet very accurate; we have only one star, Capella, for which a really good determination is possible, but for other stars rough values can be found. The terrestrial results indicate an extremely rapid change of absorption for slight alterations of wave-length (as is seen from the table); the astronomical results, on the contrary, give a nearly steady absorption-coefficient. We cannot yet detect certainly whether it increases or decreases with wave-length; at any rate there is nothing like the rapid change shown in the foregoing table. This profound discrepancy between astronomical and laboratory results leads us to inquire more deeply into the theory of absorption in a star. It will be found that there is a good reason for it.

We have been taking advantage over our cloud-bound physicist by having a preliminary peep at an actual star. We are not going to allow *him* to do that. He must not use astronomical observations to determine the opacity, but must be able to predict the astronomical value either from pure theory or from terrestrial experiments. This study is of special interest because it plunges us at once among those problems which are most exercising practical physicists at the present time. We started to explore the interior of a star; we shall presently find ourselves in the interior of an atom.

It is now generally agreed that when æther-waves fall on an atom they are not absorbed continuously. The atom lies quiet waiting its chance and then suddenly swallows a whole mouthful at once. The waves are done up in bundles called quanta and the atom has no option but to swallow the whole bundle or leave it alone. Generally the mouthful is too big for the atom's digestion, but the atom does not stop to consider that; it falls a victim to its own greed—in short, it bursts. One of its satellite electrons shoots away at high speed, carrying off the surplus energy which the atom was unable to hold. The bursting could not continue indefinitely unless there were some counter-process of repair. The ejected electrons travel about, meeting other atoms; after a time a burst atom meets a loose electron under suitable conditions and induces it to stay and heal the breach. The atom is now repaired and ready for another mouthful as soon as it gets the chance.

From this cause a big difference arises between absorption of X-rays in the laboratory and in the stars. In the laboratory the atoms are fed very slowly; the X-ray bundles which they feed on can be produced by us only in small quantities. Long before the atom has the chance of a second bite it is repaired and ready for it. But in the stars the intensity of the X-rays is enormous; the atoms are gorged and cannot take advantage of their abundant chances. The consumption of food by the hungry hunter is limited by his skill in trapping it; the consumption by the prosperous profiteer is limited by the strength of his digestion. Laboratory experiments test the atom's skill in catching food; stellar experiments test how quickly it recovers from a meal and is ready for another. That is why the absorption follows a different law in the two cases.

Capture of Electrons.

To predict the stellar absorption-coefficient we must accordingly fix attention on the rate of repair of the burst atoms. The atom is wandering about advertising a vacancy for an electron, and numbers of ejected electrons are rushing about on holiday. Many electrons will come up, look at the situation, and go off again. How is the atom to trap the electron into taking up the situation? I will give you the solution of this problem which I am inclined to think fairly probable, though I have not found many who agree with me. We may compare the electron to a stray planet entering the solar system from outside, bearing in mind, however, that the planets (satellite electrons) must be supposed to repel the invader, and the sun (positive nucleus) attracts it. Dynamics teaches us that, provided no actual material collision occurs, the intruder will scarcely ever be captured, but after stirring up things a little will retreat again towards infinity. There are exceptions, as when the sun and Jupiter conspire to capture a comet, but these would be very rare in the conditions corresponding to an atom. In some cases the intruder would turn the tables by carrying off a regular planet, thus compensating for the occasions when it was itself captured. Probably, as regards repair of the atom, as much harm as good would be done on the average.

More delicate persuasion being of no avail, there seems nothing left but for the atom to secure its electron by brute obstruction. For this reason I take the view that usually the capture of an electron occurs through its running against the positive nucleus of the atom. This nucleus has a highly complicated structure, the iron nucleus, for example, consisting of 86 distinct charges arranged in some kind of equilibrium. If by accident an electron runs full tilt into this packed mass, it will agitate it and lose energy in so doing; it will rebound, no doubt, but with smaller velocity insufficient to carry it out of the sphere of attraction of the atom.[3] By a process of exclusion this seems the only method consistent with dynamical laws by which the atom can secure the electron needed for its repair. Therefore I have concluded that the actual electron trap is none other than the positive nucleus—a region at the centre of the atom known to be about 10^{-12} cm. in radius. It must be remembered that the nucleus attracts the electrons and will sweep into the trap many which were not initially aimed at it.

This theory has been adversely critised mainly on the ground that it is entirely accordant with the laws of dynamics. At first sight that might not seem a grave objection; but we have got so used to the atom behaving in a way which violates the classical laws, that any theory which does *not* violate them is liable to be viewed with suspicion. While admitting that there are uncertain possibilities in the mysterious region in the interior of an atom, we must note that the present problem belongs to a class of investigations in which the usual dynamical laws are applied by physicists, often with much success. It concerns the motion of a free electron—not yet forming part of any permanent quantised system—a problem which occurs in the theory of conduction of electricity in metals, in thermionic phenomena, and in the scattering of α- and β-particles. In these problems physicists are accustomed to assume (rightly or wrongly) that the classical laws of dynamics are observed, and we have only followed their (good or bad) example. In particular in Rutherford's experiments on scattering, the classical laws of force are found to hold good almost to the boundary of the nucleus itself. There seems to be a fair presumptive evidence that our stellar problem should be attacked in the same way; although we admit that unknown circumstances may intervene.[4]

The strong point in our favour is that this theory

[3] The kinetic energy at the moment of collision with the nucleus is enormously greater than the kinetic energy before entering its sphere of attraction; so that a very small *proportionate* change of kinetic energy by collision would wipe out the original energy of the electron. The imperfect elasticity of the collision is a dynamical consequence of the complex structure of the nucleus. A collision of two simple charges may be perfectly elastic, except that that would apparently prevent a hydrogen nucleus from ever recovering its electron.

[4] While the fast-moving particles undoubtedly penetrate the atom in the way we have assumed, it is held by some that slow-moving electrons (as in the stars) are turned back at the surface. The idea seems to have originated at a time when the positive charge of the atom was thought to be a large sphere coextensive with it; and it seems out of keeping with modern views. It is ignored in current theories of conduction of electricity. Even if it were conceivable that a neutral atom could so ward off an electron, the strongly positive atoms in the stars could scarcely exclude it.

actually does give a value of the absorption-coefficient agreeing with astronomical observation. Thus for Capella the calculated value is 110 as compared with the observed value 150. There are certain doubtful factors which permit of the result being varied by a factor 2 or possibly 3; and we lay no stress on the precise accordance. But it appears to be possible to predict on this hypothesis the brightness of a star of known mass like Capella to within a magnitude, which amply solves the problem proposed to our physicist on the cloudy planet. It may be added that the theory also explains why the absorption in giant stars is nearly independent of the wave-length; but that is a more elementary result which becomes apparent as soon as we realise that the problem is concerned with the rate of repair of the atoms; many alternative theories of the conditions of repair would lead to the same conclusion.

Source of Stellar Energy.

The store of ætherial heat and the store of material heat in the star may be compared to the accumulators of a power station. We have not yet discovered the dynamos. The accumulators would run down in a few thousand years if they were not replenished. What is the source of the energy maintaining (and during the ascent of temperature increasing) this internal store? We believe now that the source is sub-atomic energy. One theory is that inside the star the simpler elements are gradually being built up into more complex elements, and energy is liberated in the process; a more drastic view is that matter is being entirely annihilated, setting free the whole of its energy of constitution. Taking the first theory, the most conspicuous known case is in the formation of helium from hydrogen. We do not know how to make helium from hydrogen, but we know that it is so made; we know also that 0·8 per cent. of the mass disappears in the process, and this must be the mass of the energy — æther-waves — liberated when the change occurs. Æther-waves weigh very light, and the energy available from this source is colossal. If 5 per cent. of the star consists of hydrogen which turns into helium as a first step in the formation of the higher elements, that would provide energy sufficient for all reasonable demands.

We might perhaps expect that the earliest stars would consist almost entirely of hydrogen, the evolution of the higher elements having little chance of beginning until the interior became hot enough to stimulate the process. But a difficulty arises here. For astronomical reasons it seems impossible to admit that even the earliest stars contain more than a very moderate proportion of hydrogen. I have referred to the fact that our calculations have been practically independent of the chemical constitution of the star; but one reservation ought to have been made—*provided it is not made of hydrogen.* Hydrogen gives results differing widely from all the other 91 elements.

To assume hydrogen as the material would in most cases destroy the general accordance of theory and observation; indeed it is a way of realising the goodness of this general accordance to note how it disappears when hydrogen is substituted instead of a normal element. I think, therefore, that the process of element-building from protons and electrons must have begun before the stellar stage is reached. This is a curious detached piece of knowledge to have come across in exploring the interior of a star—to be able to deny that it is mainly composed of hydrogen though any of the other 91 elements may be present to any extent; and it is still more curious that hydrogen should be the element which we were tempted to build the stars with, so that this apparently random denial hits the mark.

Admixture of hydrogen diminishes the proportion of ætherial energy and ætherial pressure, and so permits gravitation to aggregate larger masses. The occasional formation of stars of exceptionally large mass (20 to 80 times the sun's) may be due to the accidental prevalence of hydrogen in the region where they originated—that is to say, the material was in a more primitive state as regards evolution of the elements.

We need not be greatly concerned as to whether these rude attempts to explore the interior of a star have brought us to anything like the final truth. We have, I think, been able to recognise some of the leading factors participating in the problem and to learn how many varied interests are involved. The partial results already attained correspond well enough with what is observed to encourage us to think we have begun at the right end in disentangling the difficulties, and we do not anywhere come against difficulties which appear likely to be insuperable. The fact is that gaseous matter at very high temperature is the simplest kind of substance for a mathematical physicist to treat. To understand all that is going on in the material of a desk, for example, is a really difficult problem almost beyond the aspirations of present-day science; but it does not seem too sanguine to hope that in a not too distant future we shall be able to understand fully so simple a thing as a star.

vol. 12, No. 3) introduces facts which cannot be explained on the ordinary Mendelian basis. The sweet pea Duke of Westminster sometimes has on the wings a larger or smaller patch of purplish pink. Such patched plants give normal, red, and patched off-spring in varying proportions. Certain branches of "patched" plants are sometimes normal. The seeds from such normal branches show no constant genetic difference from the rest of the plant, nor was any evidence obtained that the normal, patched, and red flowers on a patched plant differed from one another genetically. There is no indication of genetic differentiation in the germplasm of different parts of the plant. Nevertheless, patched plants are not apparently all alike. As in striped Mirabilis, the pair of colour characters may behave either as a segregating Mendelian pair or form a mosaic. There is no sufficient explanation of this mosaic condition at the present time, but it represents a condition differing distinctly from ordinary Mendelian behaviour.

In a second paper on the inheritance of characters in some of the many rice varieties, Mr. F. R. Parnell, with the assistance of Messrs. G. N. R. Ayyanger, K. Ramiah and C. R. S. Ayyangar (Mem. Dept. Agr. India, Botany, vol. xi. No. 8), deals with the colours of glumes and grain, also with dwarfing and with shape of grain. The dwarf variety differs very markedly from the type, but behaves as a simple recessive. A result of economic importance is that the weight of the grain varies with the shape. The hereditary behaviour of a number of colour factors is analysed. Another genetic paper of economic value is a study of certain forms of cotton by Mr. Ram Prasad (Agric. Inst. Pusa. Bull. No. 137). Long fibre is considered to be a dominant character in cotton. Some evidence is obtained that long fibre is correlated with long stigma, plants with short lint having shorter styles. If this is the case it would enable roguing of undesirable plants producing short lint to take place much earlier than would otherwise be possible.

Norway and Iceland: An Interesting Contrast.

NORWAY has many interesting features to a visitor with scientific and technical tastes. The ubiquity of electricity generated from water-power has often been the subject of comment. The peculiar formation of the high tablelands, with lakes at heights of 1000-3000 feet, constantly renewed by water from the snows above, is favourable to hydro-electric supply. The potential value of the water-power of Norway has been assessed at 15,000,000 h.p., of which about one million is at present in use.

The mountainous nature of the country has other interesting consequences. One curious result is that communication between valleys is often less easy in summer than in winter, when roads and passes become covered with deep snow and can be traversed by ski and sleigh. The nature of the country has developed isolated scattered communities with pastoral tastes and special local industries, such as the hand-woven fabrics for which Norway is famous.

The climate has much in common with that of England. Bergen is notorious for its rainfall, and the humid atmosphere is doubtless responsible for the luxuriant growth of trees, springing in masses out of the bare rock lining the fiords in a manner that seems to invite study by experts in forestry. The use of timber in Norway is universal. Buildings are almost invariably of wood, and the humbler cottages are roofed with turf, which seems to thrive in the moist atmosphere. In mountainous Norway grass is scarce. Hence the custom of sending cattle up to the mountain "sæters" in the summer, so that the grass at the level of the fiord can be stored in summer-time. This cut grass is hung up to dry on horizontal lengths of wire. Possibly British farmers could take a hint from this practice, as crops in this country are often spoiled by rain.

Geologically the great tablelands of Norway, with their stretches of perpetual snow at relatively low level, and their vast glaciers (the largest in Europe with the exception of those in Iceland) are of great interest. It is a strange sight to find these great glaciers descending right down to the level of the fiord, as happens, for example, at Fjaerland.

Iceland furnishes some interesting contrasts to Norway. The climate is more stable and less like that of Britain. Whereas in Norway trees are everywhere, in Iceland there are practically none. Hence we find a new material for buildings of the better class—corrugated iron! Grass is also scarce, and Iceland is one of the few countries where rabbits will not thrive. The scenery, though almost destitute of verdure, is not monotonous and has a charm of its own. It consists mainly of alternations of rock, lava, and sand, with, on the lower slopes of mountains, stretches of moss. All vary remarkably in colour. Rocks are black, brown, purple, and occasionally bright red. Sand may have any tint from yellow to black. Amazing changes in colour, difficult to explain and offering an interesting study to the physicist, occur as the sun sets. A curious feature is the astonishing brilliancy of the setting sun, exceeding by far that usual in England. The pools of molten lava also afford a field for study. Their position is indicated by a sulphur-yellow crust, but the upper liquid contents are often bright blue, changing to scarlet at a lower level. Hecla, by the way, although the mountain best known to English readers, is by no means the best example of volcanic action, and is a comparatively inconspicuous mountain.

Ice and snow, usually not far distant in Norway, are universal on the higher mountains of Iceland, and the blanket of ice and snow creeping over the edges of precipices forms an important element in the general scheme of coloration.

In one respect Iceland and Norway seem to be much alike—in the hospitality accorded to the English visitor. In Norway, especially when one leaves the beaten track, one is conscious of an atmosphere very different from that in many hotels in Europe. In Iceland, once he leaves the capital, the traveller finds practically no hotels, but he can rely on the generous hospitality of the districts visited. Ponies are the usual mode of conveyance. It is stated that the import of horses is forbidden, as the Icelandic Government desires to keep the strain of ponies pure.

In Norway the present writer was impressed by the high general level of education. One could converse on equal terms with persons of all degrees, and learn facts of interest about the country. English is a compulsory language in the schools, and is often spoken with considerable facility. Even in Iceland, it appears, English is spoken more frequently than might be expected. Here again there is a high level of education, but owing to the remoteness of the island some strange conceptions of England prevail.

In Iceland, as in Norway, a variant of Danish is