THURSDAY, MAY 7, 1914.

CANCER.

(1) *The Pathology of Growth: Tumours.* By Dr. C. P. White. Pp. xii + 235. (London: Constable and Co., Ltd., 1913.) Price 10*s.* 6*d.* net.

(2) *Researches into Induced Cell-reproduction and Cancer, and other Papers.* Vol. iii. By H. C. Ross, J. W. Cropper, E. H. Ross, H. Bayon, W. J. Atkinson Butterfield, E. Jennings, and S. R. Moulgavkar. The John Howard McFadden Researches. Pp. 149 + xvii plates. (London: John Murray, 1913.) Price 5*s.* net.

(1) THIS volume seems to promise a series on the pathology of growth, under the editorship of Prof. A. E. Boycott. The venture is a welcome one showing that the move towards a closer union between pathology and physiology is making progress. Pathology is still so often restricted to, or actually confounded with, mere morbid anatomy that the wider recognition of disturbance of function—in the case of this volume of abnormality of growth—as a department of physiology proper, can only contribute both to a more wide-visioned outlook on the processes of disease, and also equally to a more critical attitude on the part of those whose sphere of activity proper is the investigation of disease, and not of normal function or structure.

For the volume as a whole we have nothing but praise, although in one relating to the pathology of growth it seems that taking up about half of it with the classification and histological structure of tumours is a liberal allowance. Especially the space devoted to Hodgkin's disease may, with profit, be omitted in future editions, since it is doubtful whether it is rightly included in a discussion of tumours proper. Since also the book is intended for students, it appears that some of this space might with profit have been yielded to the description of naked-eye appearances.

The chapters on growth, hypertrophy, atrophy, regeneration, and kindred topics are well and lucidly written. The inclusion in a text-book of pathology of a full discussion of the statistics of cancer is a welcome innovation, to which even more space might have been spared from classification, since the full significance of the statistical facts can only be brought out by giving detailed consideration to the anatomical or site distribution of cancer. Had this been done, the author would scarcely have committed himself to the general statement that cancer is increasing, since the last three annual reports of the General Register Office show that the question of the increase of cancer exists only for certain parts of the body, but not for others.

The book is, notwithstanding these criticisms, a valuable one for the student and for all who wish to have an objective review of what morbid anatomy and histology, experiment, and statistics have yielded together in the effort to elucidate cancer.

(2) The modest short title of this volume—"Researches into Induced Cell Proliferation and Cancer"—and, indeed, also the full title, do not convey adequately the enormously wide scope of the fourteen original papers which form its contents. The word "cancer" occurs in the title of one paper only: "Epithelial cell proliferation"; "The cell division of leucocytes demonstrated"; "Fibro-adenomatous nodules induced *de novo*"; "Cell division figures induced in human blood platelets"; "Treatment of wounds"; also each occur once, and presumably these are the papers for which it is claimed that "The Howard Mcfadden Researches" into induced cell proliferation bear upon cancer. The other eight papers deal with scarlet fever, measles, and syphilis, the cultivation of trypanosomes, a parasite of the earthworm, and the nature of "Kurloff's bodies" found in the leucocytes of guinea-pigs, etc.

Each subject taken up is a big one. The extent and diversity of the ground covered in this small volume of 149 pages will not cause cavil at its contents being described as researches, on the part of anyone not having precise knowledge of any of the many subjects of which it treats. Indeed, they may well marvel at the versatility displayed and the exact statements made about pitch, cancer, the classification and nomenclature of the "protozoal parasite in syphilis," and the division of polymorphonuclear leucocytes and of blood platelets. As regards syphilis, those who were present at the last meeting of the Pathological Society of Great Britain will recall the destructive criticism passed upon very similar claims regarding what was put forward as the life cycle of the cause of syphilis. The statements regarding the parasitic nature of Kurloff's bodies have not been confirmed by a recent German worker.

As regards cancer, the more critical reader will ask what leucocytes and blood plates have to do with it, and if any cancerous growth has been known ever to consist of blood platelets or polymorphonuclear leucocytes. When the statement is made that Khangri cancer "affects the women" in Cashmere, he will wonder why the men have been forgotten. When it is stated that the efforts made in the past to explain that "cancerous tissue

is epithelium which has acquired malignant properties . . . have so far lacked the experimental support which enables them to rank as theories in contradistinction from hypothesis or speculations," the critical reader will again wonder if he reads aright, because there is absolutely nothing new in the particular "experimental support" adduced, namely, the results of subcutaneous injection in the ear of the rabbit. The appearances obtained are duplications of those described for the same site after the same procedure by Fischer as long ago as 1906, and by many other authors since. Furthermore, these appearances have been the subject of years of discussion among pathologists, who are agreed they have nothing to do with cancer.

As regards "adenomatous nodules produced *de novo*," the description of nodules in the ducts of the mammary gland of goats is most superficial and imperfect; but it recalls the papillomata in the bile ducts of the rabbit, found in association with coccidiosis, another familiar appearance having nothing to do with cancer.

The whole superstructure is raised on the basis of the authors' assumption that they made polymorphonuclear leucocytes divide on a microscopical slide in 1909; the result described does not separate the cover glass from the slide by its surprising amount and rapidity, but only amounts to an increase of 10 per cent. of the number of leucocytes. This, even if correct, is but a sorry achievement when it is sought to explain normal or malignant growth, and it is forgotten that bacteria add 1000 per cent. to their weight in a few hours, and the embryos of rabbits and other mammals and birds grow at least 1000 per cent. daily, without the assistance of the results of researches into induced cell proliferation.

E. F. B.

PURE AND APPLIED MATHEMATICS.

(1) *A Textbook of Elementary Statics.* By Prof. R. S. Heath. Pp. xii + 284. (Oxford: Clarendon Press, 1913.) Price 4*s.* 6*d.*

(2) *A Shorter Algebra.* By W. M. Baker and A. A. Bourne. Pp. viii + 320 + lix. (London: G. Bell and Sons, Ltd., 1913.) Price 2*s.* 6*d.*

(3) *Key to "A New Algebra."* By S. Barnard and J. M. Child. Vol. ii., containing parts iv., v., and vi. Pp. 447–915. (London: Macmillan and Co., Ltd., 1913.) Price 8*s.* 6*d.*

(4) *Practical Surveying and Elementary Geodesy.* By Prof. Henry Adams. Pp. xii + 276. (London: Macmillan and Co., Ltd., 1913.) Price 4*s.* 6*d.* net.

(5) *Practical Science for Engineering Students.* By H. Stanley. Pp. vii + 166. (London: Methuen and Co., Ltd., n.d.) Price 3*s.*

(6) *Bell's Outdoor and Indoor Experimental Arithmetics.* By H. H. Goodacre, and E. F. Holmes, C. F. Noble, P. Steer. *First Year's Course* (Standard iii.), pp. 30. Price 3*d.* and 4*d.* *Second Year's Course* (Standard iv.), pp. 32. Price 3*d.* and 4*d.* *Third Year's Course* (Standard v.), pp. 39. Price 3*d.* and 4*d.* *Fourth Year's Course* (Standard vi.), pp. 39. Price 4*d.* and 6*d.* *Fifth Year's Course* (Standard viii.), pp. 48. Price 4*d.* and 6*d.* (London: G. Bell and Sons, Ltd., 1913).

(1) THIS is a delightful book that will rejoice the heart of the students of Birmingham and of many another university. No longer have we the problem of the elephant balancing upon a ball, the ball a foot in diameter and the elephant of negligible mass. In place of the old artificial kind we have, all the way through the book, entrancing problems from everyday life. In method of treatment also Dr. Heath's sympathies are of the widest. We find the link-polygon freely used, and that useful lettering device of Bow's not despised. We find graphical methods given their due place; we find bending moments duly treated; we find so many good things that the book, though apparently designed for the pure mathematician, ought to be adopted by the engineer also.

One suggestion we offer for the next edition, that kinetic friction, as in a journal (p. 208), should be distinguished from static friction, as in the freewheel friction clutch (p. 201).

(2) The Shorter Algebra is a good book of the old style. It gets all the tools ready first, beginning with seven pages of definitions and similar fundamentals. The preparation of the tools takes six chapters, formal equations come in chapter vii., and the first contact with life is found in chapter ix., in the application of equations to problems.

The method of this book is quite a good one for the able pupil who grasps the rules and enjoys the game. We fear it is valueless for the mediocre pupil, who does not see that it is a game and cannot understand the rules. He learns only to think himself a fool, which is often not the case; even if it is the case it is a mistake to let him think so. Constant contact with life is the only successful way to teach an abstruse subject like algebra to the mediocre boy.

The authors sternly refuse, while dealing with algebra, to recognise the existence of geometry. Two results dropped from the sky appear on page 103; do the authors hope to conceal their geometrical origin? If the pupils have even a suspicion, the watertight bulkheads are seriously

endangered; and the authors write so clearly that we fear the pupils will actually know that a jet of geometry has pierced the algebra bulkhead.

But we must not let amusement at these foibles hide the real excellence of the book. As is to be expected from the ability of its authors, the book is one of the best of its kind. As signs of their good judgment we may mention that long multiplication and long division are marked for omission on a first reading, and that in graphs statistical curves come first.

We do not understand why the authors should say that 3·5 is nearer to 4 than to 3. If words have any meaning, either 3 or 4 may be given as the "nearest integer to 3·5."

(3) Barnard and Child's "Key" is clearly and concisely written, printed in very good type and nicely set out, and (so far as our sampling shows) correct. The good appearance is increased by appropriate use of the solidus, a symbol which is used by remarkably few writers in proportion to its real value.

(4) Prof. Adams's book contains in concise form and on the whole well-expressed all that the surveyor can possibly need for work in the town and in the country, for engineering or for railway work. We are sorry to see that the recurring decimal is still in use (p. 161). In the appendix, some questions (*e.g.*, 94, 166, 169) contain references to matter that is not supplied; it would be better to omit such questions altogether.

(5) The Practical Science consists of suitably chosen experiments, the printer's type is pleasing, and, except in the introductory chapter, the headings stand out effectively. The book covers heat, mechanics, electricity, and a number of miscellaneous things, and the student who carries out the experiments will have a good elementary equipment. The treatment of friction and the funicular polygon deserves special praise; the friction treated is kinetic, which for engineers is more important than static. The text is in general clear, but here and there it is condensed to the verge of unintelligibility. The references to the diagrams should be clearer, and the lettering of the diagrams be made to correspond to the text. Numerical results should be calculated to a suitable number of significant figures, and not left in a form involving the signs of multiplication, division, and square root.

With a little care in revision, the next edition should be really valuable.

(6) The idea of the Experimental Arithmetics is excellent. The pupil trained in this experimental way will obtain a grasp of arithmetical operations incomparably greater than was possible for the average pupil in the bookish days. And the idea is well carried out by experiments to be performed indoors and out of doors on the measurement of length, area, volume, weight, and angle.

Some secondary schools follow the rule "every lesson an English lesson," and we should like to see this rule adopted in elementary schools. When that day comes, the language of these books will need to be given greater precision; for the present time the language is sufficiently clear.

D. B. M.

BOTANICAL CATALOGUES AND MANUALS.

(1) *Catalogue of Hardy Trees and Shrubs Growing at Albury Park, Surrey.* Compiled by A. B. Jackson. Pp. viii+66. (London: West, Newman and Co., 1913.)

(2) *Lowson's Text-book of Botany.* Indian edition. Adapted by M. Willis. With a preface by Dr. J. C. Willis. Pp. xii+602. (London: W. B. Clive, 1913.) Price 6*s.* 6*d.* net.

(3) *Coconut Cultivation and Plantation Machinery.* By H. Lake Coghlan and J. W. Hinchley. Pp. xii+128+x plates. (London: Crosby Lockwood and Son, 1914.) Price 3*s.* 6*d.* net.

(4) *Genera of British Plants: with the Addition of the Characters of the Genera.* By H. G. Carter. Pp. xviii+121. (Cambridge: University Press, 1913.) Price 4*s.* net.

(5) *The Story of Plant Life in the British Isles.* Introductory volume. By A. R. Horwood. Pp. xiv + 254 + plates. (London: J. and A. Churchill, 1914.) Price 6*s.* 6*d.* net.

(6) *Catalogue of the Plants Collected by Mr. and Mrs. P. A. Talbot in the Oban District, South Nigeria.* By Dr. A. B. Rendle, E. G. Baker, H. F. Wernham, S. Moore, and others. Pp. x+157+17 plates. (London: British Museum (Natural History); Longmans and Co., 1913.) Price 9*s.*

(7) *Plant Physiology.* By Dr. Ludwig Jost. Authorised English translation by R. J. Harvey Gibson. Supplement. Pp. 168. (Oxford: Clarendon Press, 1913.) Price 2*s.* 6*d.* net.

(8) *Plant Life.* By T. H. Russell. Pp. 71. (Birmingham: Cornish Brothers, Ltd., n.d.) Price 2*s.* 6*d.* net.

(1) MR. JACKSON'S catalogue of the trees at Albury is an interesting document, especially when considered in comparison with the somewhat similar list compiled by him of the trees and shrubs at Syon. The value of the Albury list is enhanced by notes about particular trees and details as to the dates of introduction of the various species, characteristics of particular plants, uses, hardiness, etc. It is of interest to

notice that there are some remarkably fine trees at Albury, no doubt due to the soil and sheltered situation, a black Italian poplar, for instance, being about 150 ft. high, and therefore one of the tallest trees in England. The white lime and other limes, the London planes and cedars, and a special variety, var. *alburyensis* of the black walnut, a specimen of the chestnut oak of North America, *Quercus prinus*, in addition to other trees, are worthy of special mention.

(2) Of Mr. Lowson's text-book there is not much that need be said; it is one of the series published by the University Tutorial Press, and follows the usual lines of the compressed botanical text-book. This particular edition has been prepared more especially for Indian students, but this fact is not very prominent in the text, except where the more systematic side of the subject in relation to phanerogams is treated. Otherwise, both text and figures bear a very familiar, and not very inspiring, appearance.

(3) Messrs. Coghlan and Hinchley are to be congratulated on having produced a very useful and interesting work on the coconut, which should prove of considerable value at the present time when so much attention is being directed to the cultivation of the coconut palm and the utilisation of its products. The book is thoroughly practical, and also well illustrated with reproductions of photographs, which are explanatory to the text. Soil, preparation of the land, seed-nuts, pests, copra, and machinery are among the subjects of the chapters. Careful estimates are given of the profit and loss of coconut planting, from which it would seem clear that, provided a suitable site has been chosen for the plantation, its ultimate success as a paying investment is assured. In an interesting chapter on catch crops, the value of *Coffea robusta* is emphasised. Errors appear to be few, but one misprint of *s. d.* for *l. s.* in the last column of the exchange tables at the beginning of the book should be noted.

(4) Mr. Carter's book is written with the intention of familiarising students of British flowering plants and ferns with the genera arranged according to Engler's system. In dealing with the genera of ferns, the arrangement enunciated by Bower is followed.

The characteristics of the natural families are set out clearly in detail, and the genera are arranged under their tribes in key form. The book aims at directing the attention of students to a closer study of the genera of plants, a purpose which it appears admirably calculated to fulfil.

(5) Seventy-three photographs, several of which are quite pretty, appear to be the *raison d'être* of "The Story of Plant Life in the British Isles"; we cannot see otherwise why this discursive volume was published. The author in his introduction is careful to point out the faults which underlie the systems of the great botanists of history, and seems to suggest that a study of his own work will show the way of salvation. Whether the student will really become acquainted with the distinctive characters of the different families of plants by using this work would seem a matter of doubt, but he will find in these pages a considerable amount of miscellaneous information, such as the fact that daisies grow in churchyards, that there is no need to point out the characteristic features of the ivy as "any boy or girl can name it," and so on. A large number of common and local plant names are given, which is a feature of some interest, and there is a glossary of terms at the end of the volume.

(6) The Oban district of Calabar, Southern Nigeria, has yielded a rich harvest of new species and genera of plants to the indefatigable collectors, Mr. and Mrs. P. Amaury Talbot. The district, botanically, belongs to the Cameroon region, and the flora is continuous with that of the similar geological country included within German territory. In the British area, however, there is a certain admixture of plants from the Gulf of Guinea region. The Oban district is densely covered with forest, and is the home of a great diversity of species of plants; Mr. Talbot considers there are some four hundred to five hundred per square mile. With a rainfall of about 175 in., and a soil of decomposed granite and gneiss, it is scarcely remarkable that the flora should be a rich one. A striking feature of these forests is the number of cauliflorous trees, many of which were previously undescribed, six being new species of the remarkable myrtaceous genus Napoleona, the flowers of which resemble somewhat those of the parasitic Rafflesia of the east. The collection consists of 1016 species and varieties, of which 195 are new, and there are nine new genera. The plants have been determined with but few exceptions by the staff of the British Museum, and the results with various notes by Mr. and Mrs. Talbot are presented in the volume under review, which form a fitting tribute to the industry of the collectors. It should be remembered that Mrs. Talbot while in the country made a remarkable series of water-colour drawings of a great number of the plants, and in particular of the flowers of the cauliflorous tree, which it is to be hoped will soon be published in colour. The present volume is illustrated with seventeen plates of figures, in which the more striking of the new plants are figured.

The descriptions of new species occupy 119

pages, and are followed by a systematic list of the plants collected; among these may be noted *Poga oleosa* (Rhizophoraceæ), hitherto only known from the Gaboon, which is an interesting discovery, as its seeds are rich in oil. Lists of the ferns, mosses, fungi, and lichens which were collected by Mr. and Mrs. Talbot complete the enumeration.

(7) The supplement to Jost's "Plant Physiology" consists of a translation of the alterations of the second edition of the German original, and to be appreciated must be studied hand in hand with the translation of the book. Without the original translation the supplement is, of course, valueless, and even with the book it is a singularly tiresome way of presenting new information or of correcting errors. It would, we should have thought, been of more value to produce in course of time a complete new edition of Jost's lectures, since it will be impossible to continue to bring out further supplements embodying the changes in the newer German editions as they are published.

(8) The publication of the little book entitled "Plant Life" is the outcome of a desire of those who heard these lectures at an adult school to have them in permanent form. They have been published, therefore, with many of the original illustrations, and form a clear, simple, and useful account of plant life for an audience such as that to whom they were given. No doubt much of their value and charm lay in their delivery, and we cannot think that any very useful purpose has been served by the publication of these lectures beyond that of honouring the memory of one who was, no doubt, as good a teacher as he must have been an ardent friend.

OUR BOOKSHELF.

The Physician in English History. By Dr. Norman Moore. (Linacre Lecture, 1913, St. John's College, Cambridge.) Pp. 57. (Cambridge: University Press, 1913.) Price 2*s.* 6*d.* net.

THE charm of Dr. Norman Moore's historical writing rests, as such virtue must rest, on many qualities; on his wide and curious learning sitting lightly upon his pen, his humanity living in his biographical gift, and enriched by his retentive memory, and his appreciation of the past, always informed by his mastery of modern clinical medicine. As his subject for the last Linacre Lecture Dr. Moore chose "The Physician in English History"; that is to say, not a string of all the physicians of English history, but, like the sheep in the painting of the Primrose family, so many as the confines of his hour would admit. The chosen physicians were either distinguished in themselves or came into note at momentous or picturesque occasions. Thus the lecturer gave to his audience not a procession of English physicians, a great story which would indeed be welcome at his hands, but a small gallery of medical pictures set in a historical background. With the propriety of a lecturer in his university of Cambridge, he opened his discourse with Bede's unusually interpretable narrative of the disease and death of Ethelreda of Ely. The skill of Cynifrid, who, apart from the arid cram of Isidore, was probably a fairly competent "Wundaerzt," failed to save her life. Probably Cynifrid was called in too late, after long courses of monastic quackery.

Next we are taken to the death-bed of William the Conqueror, whose mortal malady is illumined by the lecturer's parallel instances from twentieth-century St. Bartholomew's.

The pages given to Linacre himself are by no means a perfunctory tribute to the founder, but a happy blend of the physician as a man of letters moving in pleasant groups amid his brilliant contemporaries of the Renaissance, Erasmus, for example, Tonstall, and More. By a deft selection of materials from a well-stored memory, Dr. Moore thus carries us century by century to the middle of the eighteenth, giving us by the way bright glimpses of Wadham in the mid-seventeenth; then to the horizon of Swift and Pope with the flash of that tantalising meteor Arbuthnot, and bringing us at length to the great lexicographer and Dr. Brocklesby. A dainty entertainment. May the author in his spare hours give us many more of such.

Text-book on Railroad Surveying. By G. W. Pickels and C. C. Wiley. Pp. ix+263. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1914.) Price 10*s.* 6*d.* net.

THIS book gives a fair representation of American practice in railroad surveying. The subject-matter includes brief directions for carrying out the preliminary reconnaissance in various types of country, and the location of the best route. Fuller explanations follow of the setting out of circular and spiral transition curves; this section includes turn-outs, connections, and crossings. Earthwork problems are also treated. Methods are explained of shifting the location of curves in the field from that shown on the plan in order to secure better conditions of cutting or filling. The text occupies 125 pages, and the remaining 138 pages are taken up with tables giving curve functions, logarithms of numbers, trigonometrical functions of angles and earthwork. Detailed mathematical solutions are omitted, and an elementary knowledge of surveying is assumed. Judging from the terse nature of the contents, the title "Pocket-book of Railroad Surveying" would probably be more appropriate, and would convey to engineers the fact that the book will be found to be a useful companion in his field operations.

LETTERS TO THE EDITOR.

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

Crô Magnon Man: Imprints of his Hand.

WHILE visiting lately the painted caves of the Cantabrian Mountains (north Spain) with Prof. Boule, who had kindly invited me to accompany him, I took advantage of this opportunity to study the imprints of the human hands which occur on the walls of some of those caves, notably of Castillo.

It is well known that at Gargas and elsewhere the imprints are those of a small hand, such as might have belonged to the Grimaldi race, and one such small imprint I observed in the cavern of Altamina.

But in Castillo—so admirably described and illustrated by the Abbé Breuil—I was surprised to find that all the impressions indicate an unusually large hand. With the permission of Dr. Obermaier, and the kind assistance of Mr. Burkitt, I was able to obtain tracings of seven of these, and two of them are complete enough for detailed study. One is 190 mm. in length, measured from the tip of the middle finger to the wrist, the other about 200 mm. This accords with the length of the Crô Magnon hand as indicated by the description of the skeleton given by Dr. Verneau.

This, however, is not all. When a tracing of one of the Castillo imprints is superposed on a tracing of the hand of a living subject (Englishman) having the same length, a characteristic difference is at once perceived. The fingers of the Castillo hand are shorter than those of the Englishman, and the equality in the total length is produced by the greater length of the palm. But this is a peculiarity which must have occurred in the Crô Magnon hand, for Dr. Verneau has shown that in the Mentone skeletons the metacarpals are disproportionately long when compared with the phalanges.

I have made some preliminary measurements of tracings taken from the hands of twelve tall Englishmen, ranging from 5 ft. $8\frac{1}{2}$ in. to 6 ft. $0\frac{1}{2}$ in., with a mean of 5 ft. 11 in. (thus of about the Crô Magnon stature). Dividing the length of the middle finger by the length of the palm, I obtain 0·87 as the mean index, with a range of 0·77 to 1·0; while the most complete of the Castillo hands gives 0·765 and the next best 0·72 to 0·76.

Thus the existence of two distinct races in the Aurignacian age, already indicated by the Mentone skeletons and the carved statuettes, receives additional confirmation.

W. J. SOLLAS.

Oxford.

Cellular Structure of Emulsions.

IN reply to the letter of Prof. Kerr Grant in NATURE of April 16, similar phenomena to those which he describes have been found to occur with minute motile organisms in water, and with sediments of various kinds in water and other liquids. I have given an account of some of these appearances in my paper on the effect of gravity on the movements of microorganisms in the Transactions of the Royal Society, series B, vol. cci., pp. 333–390. I have also obtained similar groupings with the fine sediment which is formed in a hypo-alum bath, used for toning and fixing P.O.P. prints. If a small quantity of this is poured into a shallow vessel, the particles which are at first evenly distributed through the liquid soon become aggregated into groups similar to those described by Prof. Grant.

In the case of *Euglena viridis*, the living organisms in the dark become aggregated into groups as shown in Fig. 1, the central dark mass in each group consisting of a stream of Euglenæ moving downwards, the lighter peripheral area consisting of Euglenæ moving upwards. Various sediments when allowed to settle in liquids become aggregated in a similar manner, but without the continuous up and down movements. Thus Fig. 2 shows a sediment of osmium dioxide settling in dilute glycerine, which closely resembles the aggregation of the living cells shown in Fig. 1

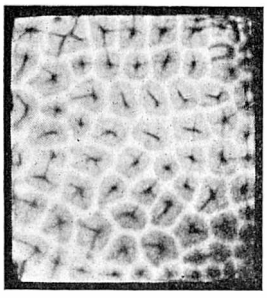


FIG. 1.

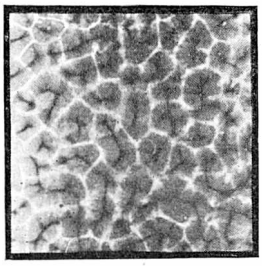


FIG. 2.

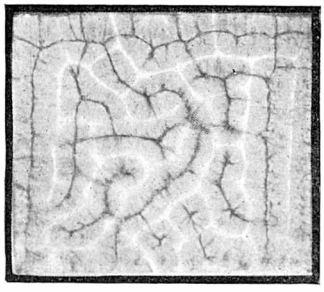


FIG. 3.

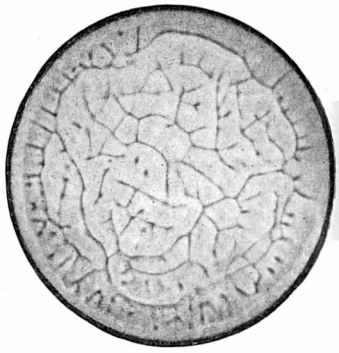


FIG. 4.

In all the cases observed by me the regular grouping appears to be preceded by the formation of a network, as shown in Fig. 3, formed by manganese dioxide settling in a solution of gum arabic. Again, if a readily oxidisable photographic developer is poured into a flat dish to form a layer about 1/16 in. deep, the brown oxidised film which forms at the surface is at once broken up into a network, Fig. 4, which gradually becomes resolved into separate groups.

I have suggested that these groupings are in all probability cohesion figures, and that they may be related to the beautiful cohesion figures described by the late Mr. C. Tomlinson in the *Philosophical Magazine* for 1861 and 1864. They are probably formed whenever we have fine particles free to move, placed under such conditions that a force or forces, acting in opposition to the cohesion of the particles, can be brought into play. Cohesion, surface tension, diffusion currents, and gravity are among the forces probably concerned in the effects observed.

Prof. Grant's suggestion that the flocculi in the solar photosphere and in cloud formations of flocculent type may be related to this phenomenon is interesting. Such flocculent appearances can also be observed, under certain conditions, in ponds and pools which contain dense aggregations of motile microorganisms, and I have very little doubt that the net-

work-like and flocculent appearances so often observed in the froth which is formed when the tide breaks on the seashore may be explained in a similar manner.

HAROLD WAGER.

West Park, Leeds, April 14.

An Extension of the Spectrum in the Extreme Ultra-Violet.

THE researches of Schumann led him to extend the spectrum to the neighbourhood of wave-length 1250. His limiting wave-length was determined by the absorption of the fluorite which formed a necessary part of his apparatus. In 1904 I succeeded in pushing the limit to wave-length 1030 by the use of a concave diffraction grating.

Recently I have renewed the attack on the problem, with the result that I have succeeded in photographing the spectrum of hydrogen to wave-length 905. The extension is due, not so much to any fundamental change in the nature of the apparatus as to an improvement in technique consequent on an experience of ten years.

It is a characteristic of the region investigated by Schumann between wave-lengths 1850 and 1250 that, while hydrogen yields a rich secondary spectrum, with the possible exception of one line, no radiation has been discovered belonging to the primary spectrum. On the other hand, in the new region between the limit set by fluorite and wave-length 905, a disruptive discharge in hydrogen produces a primary spectrum of great interest made up of perhaps a dozen lines. These lines are always accompanied in pure hydrogen by members of the secondary spectrum, but they may be obtained alone if helium containing a trace of hydrogen is employed.

Results obtained from vacuum tubes when a strong disruptive discharge is used, must always be interpreted with caution since the material torn from the tube itself sometimes furnishes impurities. In the present case, it will be some time before the effect of such impurities can be estimated. However, it may be stated with some degree of certainty that the diffuse series predicted in this region by Ritz has been discovered. The first member at 1216 is found to be greatly intensified by the disruptive discharge, and the next line at 1026 appears also, though very faintly. This diffuse series bears a simple relation to Balmer's formula. Following the same kind of argument, a sharp series corresponding to the Pickering series might be expected. The new region appears to yield two lines belonging to such a relation at the positions demanded by calculation.

THEODORE LYMAN.

Harvard University, April 20.

The Structure of Atoms and Molecules.

SINCE in an elaborate criticism of Bohr's theory on the constitution of atoms and molecules, Prof. J. W. Nicholson, as in his letter to NATURE (February 5, p 630), comes to the conclusion (*Phil. Mag.*, xxvii., p. 560, 1914) that the valencies of lithium, beryllium, boron, etc., on Bohr's theory are not in accord with experience, and if the electrons in the atoms are to be in one plane, we must either abandon Bohr's method of calculating valency—and (generally) Bohr's theory of the atoms more complex than hydrogen and helium—or give up van den Broek's hypothesis, that the charge of the nucleus of Rutherford's atom is equal to the atomic number (which hypothesis was accepted by Bohr as one of his fundamental assumptions), I may be allowed to add some remarks to my previous letter on this subject (NATURE, March 5, 1914).

For these atoms at least this hypothesis is a mere expression of experimental facts. The hydrogen atom is known to lose never more than one electron, and the helium atom never more than two, and, of course, never one to form an electrolytic ion, while lithium, beryllium, boron, and carbon can lose, or, in chemical combination, dispose of 1, 2, 3, 4 electrons respectively. Further, the number of electrons per atom has been proved to be nearly equal to half the atomic weight (Rutherford, Barkla), and in the case of carbon to be six (Rutherford, *Phil. Mag.*, vol. xxvi., p. 711, 1913). Since the number of electrons per atom must be an integer, here, at least, no other solution seems to be possible than that the number of electrons per atom surrounding the nucleus, and hence the nuclear charge, is equal to the atomic number.

Further mentioning Moseley's previous experiments on high-frequency spectra (undertaken for the express purpose of testing the atomic number hypothesis), and criticising the theoretical deductions, derived by Moseley from these experiments, Nicholson concludes that they have shown no relation to Bohr's theory (*loc. cit.*, p. 564). Now in another paper Moseley, from further experiments on high-frequency spectra, proves (*Phil. Mag.*, vol. xxvii., p. 703, 1914) that the frequency of any line in the X-ray spectra is approximately proportional to $A(M-b)^2$, where A and b are constants for each series, and M, the atomic number (called by Moseley N) of the element, is identified with the number of positive units of electricity contained in the atomic nucleus, so that these experiments "give the strongest possible support" to this atomic number hypothesis (*loc. cit.*, p. 712). The number of rare-earth elements as given by Moseley is the only exception.

That b is much larger for the "L" lines than for the "K" lines suggests, according to Moseley (in agreement with my own views, NATURE, December 25, 1913) that the "L" system is situated the further from the nucleus. If so, b=the number of electrons nearest the nucleus, and not=σ_n, the term arising from the influence of the electrons in a ring on each other, and, for the "K" lines, n, like b, must be unity, as calculated by Nicholson on Bohr's theory. For the "L" lines, according to Moseley, $b=7{\cdot}4$, but it can easily be seen from the tables that if $(M-b)$ be here augmented by 0·8 per cent., all values are integers ($\pm 0{\cdot}2$), and $b=7$ and $n=1$ again, but perhaps the factor 5/36 in Moseley's interpretation cannot be retained.

Hence, though this number 7 requires confirmation, principally, for the "K" line at least, Bohr's theory is here in agreement with Moseley's experiments, and with the atomic number hypothesis. Not only the frequencies, but also the minimum velocity of electrons required to excite this radiation, and the absorption of it (in aluminium) have been proved (*loc. cit.*) to depend on the atomic number very nearly, and Nicholson's conclusion that the atomic numbers are not correct does not hold, for $(M-b)$, not M, is one unit less for the K radiation than the corresponding atomic number. But, from analogy, Bohr's lithium atom, as well as Nicholson's ring of three electrons, must be given up, for of three, one electron (b) must be very near the nucleus, one (n) near but outside this first one, and one as electron of valency must be peripheric.

Further, the velocity of electrons, required to excite this radiation, according to Widdington equal to $10^8 \times$ atomic weight cm./sec., is more accurately equal to $2{\cdot}24 \times 10^8(M-1)$ cm./sec., than for Cr, Fe, Ni, Cu, Zn, and Se; the last formula gives for the constant reduced to unity 0·99, **1·04**, 1·02, 1·00, **0·97**, 1·00, while the first gives 0·99, 1·05, **1·06**, 0·99, 0·98, **0·94** respectively. Since the absorbability of the excited radia-

tion is only about 3 per cent. greater than that of the exciting one, and is about inversely proportional to the sixth power of the atomic number, we get $v=2\cdot23\times10^{8}(M-1)$ cm./sec., while Bohr finds $(M=N)$:

$$v=2\cdot18\times10^{8}N \text{ cm./sec.}$$

Now from this value of v, and $\nu=2\cdot47\times10^{15}(M-1)^2$, we can calculate x from $xmv^2=2h\nu$, which must be a constant, because both v^2 and ν depend on $(M-1)^2$. As $mv^2/2$ is energy to be, at least in part, radiated away periodically, on the right side of the equation, not only the number of times energy is radiated away per second (ν), but also the total time of radiation (t) and the mean energy radiated away per period (E) must occur, so that $xmv^2=2t\nu$E, and tE is a constant (which may mean only that the time during which radiation is emitted is inversely proportional, for a given frequency, to the quantity of energy that is radiated away during each period). Hence

$$x=2h\nu/mv^2=2.6\cdot62\times10^{-27}.2\cdot47\times10^{15}(M-1)^2/0\cdot88\times10^{-27}.2\cdot23^2\times10^{16}(M-1)^2=0\cdot748, \text{ or } 3/4,$$

as assumed by Moseley.

From $mv^2/a=e^2(M-1)/a^2$ we can calculate $mav=e^2.(M-1)/v=4\cdot78^2\times10^{-20}(M-1)/2\cdot23\times10^{8}(M-1)=1\cdot03\times10^{-27}$, while $h/2\pi=6\cdot62\times10^{-27}/2\pi=1\cdot05\times10^{-27}$, so that $mav=h/2\pi$, as assumed by Bohr, and

$$a=5\cdot12\times10^{-9}(M-1)^{-1} \text{ cm.}$$

All this is in agreement with Bohr's theory.

As may be seen from a previous letter (NATURE, March 5, 1914, p. 7), some properties of the elements depend not on the atomic but on the "periodic" number $P=8r\pm b$ (r is the number of horizontal rows preceding that of the element period of rare-earth elements not counted, and b the maximum or positive valency). Now the sum of these electrons of valency may be easily seen to be for all regular (non-elementar) inorganic molecules an integer multiplum of eight. Hence the same holds for the sum of all P electrons in these molecules (ions and rare-gases-atoms included). Affinity is then the tendency to build up systems of $8n$ P-electrons, and, of course, if such a molecule breaks up into atoms with each similar systems of $8n$ P-electrons, such ions must be formed as known from electrolysis. The great facility with which molecules like H_2O, NH_3, HCl, though neutral, are added to such systems, may be due to each of them, containing 8 P-electrons. According to Bohr, rings of electrons, whether belonging to one or to more atoms, may unite if the number of electrons in both is equal, so that rings of 2, 4, and ultimately 8 will be the most probable (16 only if the charge is very great).

Of course, the objections to the "Saturnian" atom hold for such systems also. Indeed, the structure of the periodic system as a whole, and the curious relation between the number of the non-periodic (Q) elements, H, He, Co, Ni, Rh, Pd, and that of the horizontal rows in the periodic system: 2/1, 2/2, 2/3, 4/3, 4/4, 4/5, 6/5, 6/6, 6/7, suggests systems of n equal non-coplanar rings of 8 electrons surrounding one or more (even n), positive nuclei, with n or $n\pm1$ electrons in or near the axis, and additional rings of electrons of valency, rather than a Saturnian atom. But, generally speaking, Bohr's theory is not in disagreement with the atomic number hypothesis.

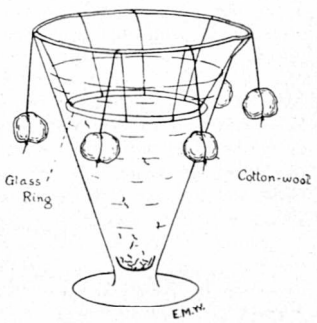
A. VAN DEN BROEK.

Gorsel (Holland), April 15.

Means of Collecting Eelworms.

THE rhubarb, when cultivated as a field crop, is subject to a wasting disease, which, attacking the root-stock and causing it to decay, occasions considerable loss to the grower. The diseased tissue, when examined, is frequently found to be infested with the stem eelworm, *Tylenchus devastatrix*, Kuhn, and, in districts where this disease is prevalent, a supply of Tylenchus material is at hand which, since the rhubarb is a perennial plant, is available not only in summer but during winter also.

When pieces of decaying rhubarb tissue are enclosed in a corked tube, any Tylenchus worms that are present migrate to the surface and, provided they have not been corked up too long, will, if placed in water, remain alive for weeks. Material can be obtained in quantity, and with very little delay, by placing pieces of rhubarb in a strainer covered with fine gauze, and suspended in a vessel of water. The eelworms, forsaking their feeding-ground, wriggle through the muslin and accumulate in a writhing mass on the floor of the vessel. This water method, it may be added, is also useful in examining the eelworm fauna of soil samples, and provides a simple means of ascertaining roughly what forms are present.



When thus collected from rhubarb, the eelworms are usually mixed with sediment, but this defect can be remedied by placing the material, while still unsorted, in a porous vessel, such as a candle-filter, which, when placed in water, allows only living eelworms to pass through. A better method of cleansing the material, however, is obtained by taking advantage of the habit that eelworms have of climbing up capillary films when these are present. For this purpose, silk threads are employed, to each of which is suspended a blob of cotton-wool, the cotton-wool serving as a receptacle for holding the crude material obtained from the rhubarb. The upper ends of the threads are attached to a glass ring which is supported upon the sloping sides of a funnel-shaped vessel containing water—this shape being chosen in order that the blobs may hang clear.

As the threads become saturated, the eelworms, leaving all impurities behind in the cotton-wool, ascend amongst the silken strands, and, passing over the brim into the water, congregate on the floor of the vessel—a feat on their part which, besides providing the student with clean material, raises the question whether, in respect of their acrobatic accomplishments, eelworms vary to any appreciable extent; and, if so, whether the rough method here described can be extended so as to provide a means of sorting out one species from another, when two or more species are present in the material employed.

M. V. LEBOUR.
T. H. TAYLOR.

The University, Leeds.

THE PROHIBITION OF EXPERIMENTS ON DOGS.

THE Dogs' Protection Bill for the second reading of which 122 members of Parliament were induced to vote the other day is one of those measures which are born of ignorance and fostered on misrepresentation. All our knowledge of the functions of the body is fundamentally based on experiments which have been made upon dogs. The action of the heart and its nerves; the

mechanisms of circulation, respiration, digestion, and secretion; the functions of the liver, pancreas, and kidney; the processes of metabolism, the causation of diabetes; the utility of the internally-secreting glands; the manner in which the organs of the body are governed and their functions regulated—none of these could have been elucidated nor could the knowledge which has been obtained have been applied to man from experiments upon animals other than dogs. The prohibition of the employment of dogs for these investigations would put a complete stop to the progress of physiology in Great Britain—which, in this particular science, has, from the time of Harvey onwards, always held a peculiarly honourable position. It would put medicine in this country at an enormous disadvantage as compared with other countries; and our professors and students would have to go abroad to gain that practical knowledge of the functions of the body for the investigation of which the dog is the only animal available. For medicine is founded upon an exact knowledge of these functions: without it the physician gropes in the dark and works by guesses which are generally far removed from the actual truth. Moreover many diseases which are common to man and animals can only be fully investigated in an animal like the dog, unless man himself is to be made the subject of experiment. And it is scarcely necessary to point out even to our opponents that the prohibition they demand would prevent any further investigation of the causation and treatment of diseases which are peculiar to the dog, so that the race they are professing to protect would ultimately suffer from such prohibition even more than mankind.

The question really at issue is whether a knowledge of the functions of the body in health and disease is to continue to be gained at the expense of a certain number of stray and worthless dogs, which are in any case condemned by law to be destroyed, or at the expense of humanity. Nothing is more certain than that important branches of medical knowledge if not advanced by experiments on these animals can only be advanced by taking toll of the lives of patients, who would be treated in ignorance of the conditions under which remedies should be applied and of the results which such remedies are likely to yield.

It is difficult for a layman to understand the full bearing of this question, because he is unaware of the extent to which medical knowledge profits and has profited by experiments on animals. Some doctors even, mostly belonging to what is often spoken of as the "old school," are uninformed regarding the manner in which their knowledge of the functions of the body and of the changes which are produced in disease has been acquired. It is, moreover, true that the ordinary practising physician does not himself make experiments upon animals: he has as a rule neither the time nor the opportunity. But however well-trained he may be, it is not the practitioner who advances our knowledge of medicine and surgery; or if he does so it is at the expense of the patient upon whom he first makes a trial of the remedies by aid of which he hopes to cure the particular disease he is treating. There are, admittedly, operations which have been tried from the first upon the human subject and have ultimately resulted in singular success, so that cases which previously would have been relinquished as hopeless are in large numbers restored to health. But the toll of human lives required to achieve this success is lamentable. Surgeons who devise a new method of operation are in the habit of publishing statistics regarding the cases which they have treated by it. An examination of such statistics always shows a relatively large percentage of failures and death in the earlier cases, whilst that percentage is greatly reduced or even abolished in the later cases. This means that the earlier cases have partaken of the nature of experiments by the aid of which the technique of the method has been established. If this technique had been worked out in dogs the toll of human life required to arrive at the same degree of perfection would have been vastly less.

There are, however, surgeons of the present day—and their number is likely to increase in the future—who consider it improper to acquire at the expense of their patients the technical knowledge necessary for the establishment of a new operative method and who would willingly resort to dogs for the purpose of obtaining such knowledge. This procedure can, however, be but rarely carried out in this country, because the anti-vivisectionist legislation of recent years places serious obstacles in its path. But in the United States, where a more enlightened view is taken of the position of mankind in relation to the lower animals, it is the recognised method of procedure, and is beginning to make itself felt in the extraordinary progress which the science and practice of surgery has made of late years in America.

Sir Frederick Banbury has attempted to excite sympathy for his Bill by citing the case of a dog which had been operated on by an eminent Edinburgh surgeon, with the object of testing a new method of inducing union of fractures of bone. Surely nothing could be more proper than that a new method should be first performed upon a dog rather than upon man. Does Sir Frederick Banbury think that it would have been right for the test to be first made upon a patient? Would he prefer to have an untried method applied to himself before it had been determined, by experiments upon dogs, whether it could be successfully performed or would be likely to yield a good result? I think the Edinburgh dog is an unfortunate instance for Sir Frederick to have selected. And I cannot, of course, expect him to see that the fact that the dog, which was bought in good faith from a known dealer in animals, happened to have been picked up in the street by the vendor, has nothing to do with the question whether it is or is not expedient to employ dogs for this and similar purposes.

Sir Frederick Banbury is commonly believed to be impervious to argument and one can well

understand that this may be so; otherwise he would surely be able to see that the very statistics which he gives regarding the number of dogs utilised in this country for medical research furnish the strongest of arguments against his Bill. Does he think that men who are engaged in these researches *prefer* to employ dogs, and insist on using them, rather than cats or rabbits or guinea-pigs—for which Sir Frederick evidently has but little sympathy—for no other reason than the sheer desire to vivisect them rather than other animals which are far cheaper and more easily obtained? Is he not able to understand that dogs are never employed and are never likely to be employed for experiments unless there is some special necessity for using these animals rather than others? At any rate he may accept my assurance that it is so. And it follows that the greater number of dogs he can show to have been used the stronger is the argument for the necessity of using them. Not that his statistics are of much account, for in attempting to strengthen his case for dogs, he mixes cats up with them—unless the report of his speech is in this respect inaccurate.

But Sir Frederick Banbury's inability to assess evidence is sufficiently manifested by his argument that because the Royal Commission did not specifically state in its report that it is necessary for dogs to be employed it found no evidence sufficiently strong to authorise it to make such a statement. We know, as a matter of fact, that the Commission did discuss the question whether the exclusion of dogs might be recommended and definitely concluded against the adoption of this course. Is it, perhaps, possible that Sir Frederick Banbury—who puts himself forward as a judge in this matter—has not himself read the evidence which was presented to the Commission on the subject? This is the only hypothesis that I can suggest to render his position intelligible. But this hypothesis cannot be applied to Col. Lockwood, who appears as Sir Frederick's chief supporter—since he was a member of the Commission. Although he does not dare to say that the evidence before the Commission proved that the use of dogs is not necessary, he alleges that it did not distinctly prove "to anyone with a fair mind" that the dog alone is necessary for those "so-called scientific experiments" (*sic*). And this in spite of the fact that it had been proved to demonstration before the Commission—what is, of course, well known to any person who has any medical knowledge worth speaking of—that most of what we know regarding the functions of the body could only have been elucidated with the aid of experiments on dogs.

Col. Lockwood is, however, good enough to inform us by what consideration he is guided. He is "not ashamed to say that he is actuated by sentiment." But there is sentiment and sentiment, and we may be permitted to inquire what kind of sentiment it is that actuates Col. Lockwood. Sentiment is feeling and Col. Lockwood's feeling is for the lower animals in general, for dogs in particular, and probably—if it were to be still further analysed—most particularly for the special dog which, as he tells us, he leads about London on a string. His sentiment does not extend to humanity. He has no feeling for his own species. He prefers that mankind shall continue to be ignorant, and shall continue to suffer as a result of that ignorance, rather than that his feeling for dogs, most of which do not in any way suffer, shall be harrowed.

Sentiment of this sort has no true ring: it is *false* sentiment; and any man—let alone a legislator—should be ashamed to confess that he is actuated by it.

Further, Col. Lockwood is good enough "not to wish to accuse his opponents of not being so humane as himself." But Col. Lockwood's humaneness is—like his sentiment—*false*: it leaves humanity out of consideration. He may take it from me that his opponents repudiate this kind of humaneness and thank him neither for the comparison nor for his eulogium of their profession. Of what value is eulogium coming from such a quarter? If he and his 121 fellow-members accept the services of medical men, are they not benefiting by the very experiments they denounce? To be consistent they should resolutely decline to call in the aid of physician or surgeon and betake themselves to the Christian Scientist or to any other quack they may fancy. But it is as hopeless to look for consistency from anti-vivisectionists as to expect to gather figs from thistles. As for the voters who send such persons to Parliament, one may well apply to them Carlyle's estimate of most of his fellow-citizens. But perhaps they are, on the whole, not inappropriately represented there.

E. A. SCHÄFER.

THE TREVOR LAWRENCE ORCHID COLLECTION AT THE ROYAL GARDENS, KEW.

WHEN the late Sir J. J. Trevor Lawrence, Bart., died, an announcement was made that his well-known orchid collection at Burford had been bequeathed to Lady Lawrence with an expression of his wish that such of the plants as were especially of botanical interest should be presented to the Royal Botanic Gardens, Kew. This gift has now been made to the national orchid collection there, which has received from Lady Lawrence a large selection consisting of 580 plants, belonging to 89 genera, and representing 350 species mainly, but by no means exclusively, of botanical interest.

The character of the collection brought together by Sir Trevor at Burford during many years was a matter of general knowledge. It was singularly rich in rare and interesting species, owing to the fact that Sir Trevor at all times paid especial attention to whatever in the natural family was striking or unusual from a morphological point of view, apart entirely from any decorative value which it might possess. The result of this was that the Burford collection was not only thoroughly representative of the usual showy species and hybrids and on this account to be

reckoned with in the horticultural world, but also possessed examples of most of the cultivated genera, some of which are seldom met with, and, on this account, was perhaps as important from the scientific as from the gardening point of view. It included plants from almost every quarter of the globe demanding the most diverse cultural treatment.

The magnificent selection from the collection at Burford now transferred to Kew is rich in such genera as Bulbophyllum, Cirrhopetalum, Pleurothallis, Maxillaria, Epidendrum, Eria, Angræcum, Dendrobium, and Cœlogyne, and includes many species and a few genera not previously represented at Kew, some of these being rarely seen in cultivation. The genera not previously present in the Kew collection include Trichocerós, a high Andine genus very difficult to bring home alive and very difficult to cultivate afterwards, Nasonia and Quekettia, two small American genera, and Stereochilus and Sigmatogyne from Northern India. The collection also includes a number of undetermined species which have not yet flowered; in a few cases the genus to which these belong is still doubtful. These unknown plants have been derived from various sources; some of them are plants contributed to the Burford collection by Sir Trevor's son, Captain C. T. Lawrence, by whom they were obtained in West Africa.

PROF. EDUARD SUESS, FOR.MEM.R.S.

BY the death of Eduard Suess on April 26, Austria loses her most eminent man of science, and the world one of its greatest naturalists. The son of a German merchant, domiciled in this country, Suess was born in London on August 20, 1831. The family removed, while he was still young, first to Prague and then to Vienna—but to the end of his life Suess retained his affection for what he used to call his "native land," and maintained the most cordial relations with his numerous English friends. His university career was commenced at Prague, but completed in Vienna, and at the age of twenty-one he became an assistant in the geological department of the famous Natural History Museum of the latter city. Here he worked for five years on the collections, and, as the result of his studies, published a number of important papers on graptolites, brachiopods, and other fossil forms.

It was in 1857, however, that Suess entered upon what was his life's great work—that of a teacher. After serving ten years as an extraordinary professor in the University of Vienna, he was in 1867 appointed to the full professorship of geology, a post which he held for thirty-four years, retiring as emeritus professor in 1901. Of his success as a teacher it is needless to speak, for he numbered among his pupils Neumayr, Mojsisovics, Fuchs, Waagen, Penck, and other distinguished geologists, many of whom caught from their master that grasp of detail, combined with powers of generalisation, that so eminently distinguished him. The writer of this notice recalls with pleasure the happy time he spent with Suess forty years ago, when he had the opportunity of witnessing the delightful relations that existed between the professor and his students. Not only during geological excursions in the neighbourhood of Vienna was the charm of Suess's society felt, but in the Wurstel-Prater, where we joined the young fellows during hours of relaxation—in the beer-gardens, and even on the "merry-go-rounds." Yet, amid all the fun and frolic, the signs of affectionate respect and devotion to the great teacher were never for a moment wanting.

It was at this time that Suess's daughter became engaged to his most distinguished pupil, the young Bavarian, Melchior Neumayr. After working for a time on the Geological Survey of Austria, Neumayr had established a great reputation as a palæontologist, and at the age of twenty-eight became a colleague of Suess, as professor of palæontology in the Vienna University. Greatly impressed by reading the "Origin of Species," he entered into correspondence with Darwin, by whom his work was held in high estimation, and in the end he came to be regarded as the stoutest champion of evolution on the geological side.

Suess's own researches ranged over every branch of geological science, as may be seen from the titles of sixty memoirs and books published by him prior to 1875. But in this year there appeared his remarkable work, "Die Entstehung der Alpen," to be followed five years later by the first part of the still more famous "Antlitz der Erde." In this great work, which engaged his labours during twenty-five years, Suess aimed at no less a task than taking a comprehensive survey of all that has been accomplished in elucidating the geological structure of every part of the globe, and drawing general conclusions from that survey. How admirably this herculean undertaking was performed is told—with an estimate of the great merits, the small defects, and the enormous influence exerted by this monumental work—by Sir Archibald Geikie in a contribution to the series of "Scientific Worthies" (see NATURE, vol. lxxii., May 4, 1905). It will suffice here to say that the book will undoubtedly take its place as a scientific classic, side by side with Hutton's "Theory of the Earth" and Lyell's "Principles of Geology."

In 1890 there came a sad interruption to Suess's scientific labours. His distinguished son-in-law and colleague, Neumayr, died at the early age of forty-four, when only the first volume of the great work on which he was engaged, "Die Stämme des Thierreichs," had been published. It is very touching, even at this date, to read the letters in which Suess wrote of his great sorrow to his friends; but fortunately these same letters contained the expression of a new hope, founded on the fact that his own son had just taken his doctor's degree in geology. Happily, Suess lived to see his son become an extraordinary professor in the University, to find him the author of valuable geological papers, and, shortly before

he passed away, to witness the son installed in the chair vacated by himself only a few years previously.

The great task of his life completed in 1910, Suess's closing years have been happy and restful, for only quite recently came the bronchial affection which terminated his life in his eighty-fourth year.

Suess held much the same position among German-speaking peoples as did Huxley among English and Americans. They both held that, in addition to their scientific labours, however exacting these might be, something in the way of service was due to the cities in which they lived and the states to which they belonged. In 1862 Suess had directed attention to the unsatisfactory condition of the water-supply of Vienna, and, from 1863 to 1873, he was called upon to serve as a member of the Municipal Council of Vienna; it was due to his initiative in this capacity that an aqueduct, 110 kilometres long, was built to bring water from the Alps to the city, and that other great improvements in the sanitary conditions of Vienna were undertaken. For more than thirty years he was a member of the Lower House of the Reichsrath, and proved himself a doughty champion against the defenders of political privileges and of clericalism. Like Huxley, he declined many offers of honours and titles from the State, but was amply compensated by the marks of esteem from his fellow-workers in science. He was president of the Austrian Academy of Sciences, a member of the French Institute, Foreign Member of the Royal Society since 1894, and member of scientific societies in every part of the world. He received the Wollaston medal of the Geological Society in 1896, and the Copley medal of the Royal Society in 1903. JOHN W. JUDD.

ROBERT KAYE GRAY.

IT is with deep regret that we have to record the death of Mr. Robert Kaye Gray, who passed away on April 28, at Brighton, after a long illness, at the age of sixty-two. He was well known as the managing director of the India-Rubber, Gutta-Percha, and Telegraph Works Co. at Silvertown, but his interests extended far beyond the range of commerce, and he became associated with many institutions and societies for the improvement of natural knowledge, and for the welfare of the sick and needy. His attractive personality, his quiet way of doing good, his unbounded generosity, the breadth of his mind, and his exceptional store of worldly wisdom, made him the centre of a multiplicity of activities; and there is no doubt that in recent years the constant demand made upon his powers and judgment hastened the end of his remarkable career.

Readers of NATURE will recall how large a share Mr. Gray took in establishing and supporting the National Physical Laboratory. He had the satisfaction of seeing the laboratory extend in scope and usefulness, and his name will always be associated with that of the late Sir William White in the pioneer work of giving direction to its latent possibilities. His loss will be keenly felt by the Institution of Electrical Engineers, of which he was a past president, by the Royal Society of Arts, and the Institute of Metals, to which he rendered substantial help.

The cause of technical and university education in London has also suffered by the loss of Mr. Robert Gray, who gave freely of his time and from the fund of his experience to aid in their advance. His association with submarine telegraphy brought him into touch with engineers and others in every quarter of the globe, and it is not too much to say that he was universally esteemed and honoured.

From his father, the late Matthew Gray, an engineer of high ideals and remarkable strength of character, Mr. Gray inherited a mind intent upon accomplishing large things by straight means. Early in his professional life he set himself to master every branch of submarine telegraph engineering, including the manufacture, laying, and testing of cables. This knowledge and experience was the basis of his subsequent professional work, and it led him ultimately towards that field of natural science of a practical kind, which afforded him full scope for his energies. In the history of the progress of the age through which he passed he must be assigned a place as a representative man, and as a man of affairs. He was representative of the age in which commerce became a science, and science a refining influence —the age in which science was at last seen to be consistent with benevolence.

NOTES.

AMERICA has lost one of her foremost astronomers by the death, in his seventy-seventh year, of Dr. George William Hill. He graduated at Rutgers College in 1859, and in 1861 became an assistant in the office of the American Ephemeris and Nautical Almanack. He afterwards became chief of this publication. From 1898 to 1901 he was lecturer in celestial mechanics at Columbia University, New York. In 1887 the Royal Astronomical Society awarded him its gold medal for his researches in connection with the lunar theory. He was a foreign member of that society, and also of the Royal Society, and a corresponding member of the Institute of France. In 1892 Cambridge University conferred on him its honorary Sc.D. He was president of the American Mathematical Society from 1894 to 1896. In 1905 the Carnegie Institution published a volume of his collected mathematical works, with an introduction by Henri Poincaré. Dr. Hill was also the author of a work on "The Theory of Jupiter and Saturn."

MR. C. S. S. PEIRCE, an American mathematician and logician of international reputation, has died at the age of seventy-four. He was a son of Prof. Benjamin Peirce, of Harvard, and was himself educated at that University. For a few years he was a teacher of logic in Johns Hopkins University, and he gave occasional lectures at Harvard, but the greater part of his life was devoted to study and research. Since 1887 he had lived in seclusion in a little cabin in the

mountains near Milford, Pennsylvania, where he had collected what is believed to be one of the most complete private reference libraries in the world on the subjects in which he was interested. He edited several of his father's mathematical works, and was the author of "Photometric Researches," as well as of numerous papers on logic, the history of science, psychology, astronomy, optics, colour sense, map projections, chemistry, engineering, early English pronunciation, library cataloguing, etc. Mr. Peirce was one of the pioneers of symbolic logic, and was the first to formulate the philosophical principle which he named "pragmatism." He dissented, however, from Prof. William James's development of this principle.

WE regret to record the death, in Paris, of M. Wilfred de Fonvielle. Few men have done more to popularise the subject of aeronautics than M. de Fonvielle, who not only wrote numerous books and articles, both popular and scientific, upon the subject, but also did much practical work, especially in regard to balloons. Commencing life as a journalist, he joined the staff of a journal, *La Presse Scientifique*, edited by M. Barral. The latter had just been making his well-known balloon ascents for scientific observation, which greatly interested the young enthusiast and started him writing articles on the subject. Since then, until recently, his pen had but little rest. His principal works are:—"La Science en Ballon" (1869); "Voyages Aériens" (with Glaisher and others) (1871), translated into English; "Les Ballons pendant le Siège" (1871); "Traité Pratique de Navigation Aérienne" (1872); "Aventures Aérienne" (1876), translated into English; "La Conquête de l'Air" (1882); "Notre Flotte Aérienne" (1908); and a vast number of articles in French and English papers and magazines, including many contributions to our columns. De Fonvielle's first balloon ascent was made in the great *Géant*, with M. Nadar, in 1867. Numerous other journeys followed, until he became considered one of the leading aeronauts in France. During the siege of Paris he piloted one of the balloons which left that city, descending in Belgium, whence he crossed to England. In later years he paid frequent visits to this country, where he several times made balloon ascents. For some years he was president of the Société Française de Navigation Aérienne.

BOTANISTS will learn with regret of the death, at seventy-five years of age, of M. van Tieghem, member of the Institute of France, professor at the Natural History Museum, Paris, and one of the most eminent of modern workers in the field of botany. As a young man he worked under Pasteur, and he made valuable contributions to science in the domain of bacteriology. In 1873 he published, in conjunction with his pupil, G. Le Monnier, a monograph on the Mucorineæ, in which the morphology and physiology of the family were carefully studied, and a detailed systematic account was given for the first time. Two further contributions on the same subject appeared in 1875 and 1876. But van Tieghem is best known for his work on the anatomy and morphology of the seed-plants. In 1866 appeared an important paper on the anatomical structure of the Aroideæ, and his concluding remarks supply the key to his work in this field. He says:—"Nos observations semblent démontrer aussi par une preuve nouvelle qu'il est indispensable de joindre l'étude anatomique comparée de l'appareil végétatif à celle de la fleur, si l'on veut construire le système idéel à liaisons fixes qui est l'objet de la méthode naturelle." The systems of classification which he proposed were, however, the least valuable part of his work; they indicated lack of appreciation of the relative value of characters, and were hampered by a cumbersome terminology. On the other hand, his work on the comparative anatomy of the female flower and fruit of the Gymnosperms was of fundamental value. In 1882 he succeeded Decaisne as botanical editor of the *Annales des Sciences Naturelles*, a post which he held until his death, and the long series of memoirs in this journal by himself and his pupils on the morphology and anatomy of various families and genera of seed-plants will form a permanent monument of his industry and botanical work.

THE Bruce medal of the Astronomical Society of the Pacific has been awarded to Dr. O. Backlund, director of the Pulkowa Observatory.

Science announces the retirement, on July 1, after twenty-one years' connection with the Yerkes Observatory, of Prof. S. W. Burnham.

THE Wellcome Historical Medical Museum is to be reopened on May 28, at 54*a* Wigmore Street, as a permanent institution in London. Since the closing of the museum in October last the collections have been much augmented and entirely rearranged.

IT is announced in *Science* that the amount subscribed in connection with the jubilee celebration of Dr. A. Auwers has been handed to the Berlin Academy for the foundation of a prize (to be known as the Bradley Prize) to be awarded once every five years.

ACCORDING to the *Lancet*, it has been decided by the Liverpool School of Tropical Medicine to establish a permanent laboratory in Sierra Leone for the purpose of carrying on research work. It is hoped that the laboratory will act as a base from which expeditions to other regions of tropical Africa may be dispatched from time to time.

AN International Conference of Telegraph Engineers is to be held in Berne from September 14 to 20 next. Among the subjects open for discussion are the prospects of telephony over longer distances, the protection of telegraph and telephone wires from other electrical conductors, and how far automatic apparatus in telephone exchange working is desirable.

THE summer meeting of the Institution of Naval Architects will be held in Newcastle-on-Tyne on July 7–10, at the invitation of the institution by the president and council of the North-East Coast Institution of Engineers and Shipbuilders. Meetings for the reading of papers will be held, and arrangements will be made to visit some of the principal works in Newcastle and its vicinity.

IN order to commemorate the work of Wilbur Wright, who, with his brother, Orville Wright, evolved the first successful power-driven aeroplane, the Wilbur Wright Memorial Fund was created under the auspices of the Aeronautical Society for the purpose of providing for the annual delivery of a premium lecture. The second memorial lecture will be delivered by Dr. R. T. Glazebrook, director of the National Physical Laboratory, on May 20, at the Royal United Service Institution, Whitehall, S.W. The Right Hon. Lord Sydenham will preside.

MR. A. N. HAIL has been appointed Government curator of the Ancient Monuments of Rhodesia. According to the *Geographical Journal*, the objects under his charge will include not only ruins, but all relics wherever found, and also the Bushman paintings, all of which are in future to be protected from vandalism and preventible destruction. The headquarters of the curator will be at Great Zimbabwe, but Mr. Hall hopes, it is stated, to spend four months of each year in examining or searching for other remains.

THE Board of Agriculture and Fisheries desires to bring to the attention of the public the arrangement now established at the Royal Botanic Gardens, Kew, whereby a competent guide accompanies visitors on weekdays through the gardens and explains the many objects of botanical interest. A small charge is made for the services of the guide, 6*d*. for each person attending a morning tour, and 3*d*. for each person attending an afternoon tour. The present arrangements are of the nature of an experiment, and their continuance beyond September next will depend on the extent of the public demand for the services of the guide. A leaflet giving detailed information on the subject can be obtained on application to the director, Royal Botanic Gardens, Kew.

THE thirteenth annual general meeting of the Marine Biological Association of the United Kingdom was held in the rooms of the Royal Society on April 29, Sir E. Ray Lankester, president of the association, being in the chair. Dr. P. Chalmers Mitchell and Mr. F. A. Potts were elected to fill two vacancies on the council. In the annual report reference was made to the discovery at Plymouth of the puerulus stage of the sea crayfish (Palinurus) by Prof. Bouvier, of Paris, to the investigations on eggs and young stages of British food fishes, by Mr. R. S. Clark, on the feeding habits and rate of growth of invertebrates, by Mr. J. H. Orton, and on the culture of plankton diatoms, by Dr. E. J. Allen. Mention was also made of work carried out at the laboratory by Mrs. Matthews on the development of Alcyonium, by Dr. Mortensen on the larvæ of Echinoderms, by Dr. Shearer, Mr. De Morgan, and Mr. Fuchs on the hybridisation of Echinoderms, by Mr. J. Gray on the electrical conductivity of Echinus eggs, and by Dr. Stuart Thomson on the brain of Elasmobranchs. It was reported that Mr. D. J. Matthews and Mr. L. R. Crawshay had returned to the laboratory from the expedition of the *Scotia* to the coast of Labrador, and Mr. E. W. Nelson from the British Antarctic Expedition, and that these gentlemen had been employed in working up the material which they had obtained.

AT Greenwich the mean temperature for the month of April was 50·8°, which is 2·7° above the average. This is the warmest April for the last ten years, but there have been six warmer Aprils since 1841, the warmest being 53·9° in 1865. The mean of the maximum temperatures was 61·1°, and the mean of the minimum 40·5°. There were three days with a temperature of 70° or above; in 1865 there were fourteen days above 70°. The total rainfall was 1·12 in., of which 1·10 in. was measured during the first ten days and only 0·02 in. at Greenwich in the remainder of the month. The duration of sunshine at Greenwich was 231·6 hours, which is 166 per cent. of the average. It is the sunniest month at any time of the year since the memorable summer of 1911, and has only once been surpassed previously in April at Greenwich, 1909 having 250 hours of bright sunshine. There were thirteen days with more than ten hours of sunshine, and April 30 was the only day during the month on which the sun did not shine.

IN the recent annual report of the Decimal Association there is a reference to the legalisation of the metric carat in this country. Although the Order in Council came into operation so recently as April 1, it is satisfactory to note that the adoption of the new unit by dealers in diamonds and precious stones is already practically complete, and has occasioned little or no inconvenience. The manufacturers of weights in this country do not appear to have realised that the change would be effected so readily, and in consequence of this a large proportion of the sets of metric carat weights have been imported from the Continent to meet the sudden demand. The largest metric carat weight legalised is the 500 C.M., which is equivalent to 100 grams. Many diamond dealers who have been accustomed to use weights up to 5000 carats were inclined at first to imagine that such large single weights would not be permissible in future, but they now understand that above 500 C.M. the ordinary metric series, 200 grams, 500 grams, kilogram, etc., may be employed, and little difficulty is experienced by them in adapting their operations to the new conditions.

THE Peabody Museum of American Archæology and Ethnology, Harvard University, publishes a fine monograph by Mr. A. M. Tozzer on the prehistoric ruins of Nakum, in Guatemala. The museum expeditions since 1888 have been engaged in exploring the Maya area in Mexico, Guatemala, Honduras, and British Honduras. Unfortunately, these interesting ruins have suffered much from fires lighted by natives to clear the ground for cultivation, and from sheer vandalism. Quite recently some of the sculptured stelæ at Copan were destroyed to make the foundations for an adobe wall. Several ruined cities have been discovered, and it is well that the surveys now in progress should be undertaken while the material remains undisturbed.

THE *Times* of April 25 publishes a preliminary report on the excavations at the Great Stone Circle

at Avebury. The work has extended to the silting of the fosse on the east side, and against the solid chalk entrance causeway on the south of the great circle. A few antler picks and hammers and a finely worked flint implement have already been found in the chalk rubble, and in the Roman stratum nearer the surface a ring and part of a bracelet, both of bronze. In the cutting of the vallum have been decovered two red deer antlers and an interesting bone pin nicely worked and polished. The old surface line has been reached in places, and is clearly defined; on it have been found several small fragments of prehistoric pottery, a flint scraper, and two flint saws, as well as clear traces of charcoal.

ACCORDING to the April number of the *Museums Journal*, the chief loan collections at the twenty-fifth conference of the Museum Association, to be held at Swansea in July, will comprise Welsh pottery and porcelain, paintings by old masters and modern Rouen artists, Rouen decorative metal-work, and old Welsh furniture and lacquer.

AMONG questions discussed in Publication No. 2169 (Opinions 52–56) of the International Commission on Zoological Nomenclature is the validity of the names, which were edited by Linnæus, in Hasselquist's "Iter Palæstinum"—published prior to 1757. It is ruled that these are invalid, despite the publication of a German translation of the volume in 1757, which, it had been urged, might justify their recognition.

THE surface-swimming copepod crustaceans of the Gulf of Manaar form the subject of the longest article, by Capt. R. B. S. Sewell, in No. 35 (vol. ix.) of *Spolia Zeylanica*. The account is mainly based on two collections—one made between 1906 and 1909 inclusive, and the other in 1913; these embrace a total of eighty-seven species and subspecies, of which five are described as new. This number also includes the second part of a paper by Dr. J. Pearson on the holothurians of the Indian Ocean, together with a revision, by the same writer, of the genera Muelleria and Holothuria.

IN the introduction to a long reply on certain criticisms of the theory of mimicry, the greater portion of which appears in the January issue of the Proceedings of the Academy of Philadelphia, Prof. Poulton remarks that more definite evidence than we at present possess with regard to the butterfly-eating habit in birds, and that some species of butterflies are nauseous to them, is urgently required. Such evidence is, however, steadily increasing, an important item coming from Uganda, where a wagtail, after eating butterflies belonging to two groups, rejected one representing a third.

"ELVERS," writes Mr. J. S. Elliott in an article on eels and eel-catching in Bedfordshire in the April number of the *Zoologist*, ascend the Ouse and its tributaries in swarms from the Wash. From the time of Domesday Book most Bedfordshire mills have been provided with eel-traps, which in early days furnished a considerable instalment of the rent. Although apparently less than formerly, the total average catch in the county is now about 3 tons 18 cwt., representing something like 17,500 eels, with a value, at the local price of 6*d*. a pound, of practically 220*l*.

To the March number of *Naturen* Mr. Ørjan Olsen contributes an illustrated account of the whales of South Africa, and whaling as carried on at Durban and Saldanha Bay on the east, and at Port Alexandre, Benguela, on the west coast. A considerale amount of space is devoted to *Balaenoptera brydei*, the new rorqual described by Mr. Olsen last year, of which 169 individuals were taken in 1912. In the following year, up to July, 92 common fin-whales and 36 blue whales were captured at the Saldanha Bay station. The other species taken were the southern humpback (*Megaptera boöps*, or *nodosa, lalandei*), the southern right whale (*Balaena australis*), which is very rare, and the sperm-whale.

PHOTOGRAPHS of two recently added animal groups appear in the report of the American Museum of Natural History, one representing the reptile life of the Californian cactus-desert tract, and the other showing portions of two piles grown over with mussels and sea-anemones from a group illustrating the fauna of submerged timber. An item in the report well worthy the attention of museum curators in this country is a photograph of fireproof cases recently installed for the storage of mammal skins. If this is worth doing in America, it is still more so in our our own Natural History Museum, with its priceless series of "type" specimens. Even if the new method of storage could not be applied to the whole study-collection, it might be employed for types.

DR. ENRICO FESTA has utilised the opportunity presented by the Italian occupation of Rhodes to visit the island for the purpose of studying its fauna. An account of his observations, and reports on his collections have recently been published (*Bolletino dei Musei di Zoologia ed Anat. comp. della R. Università di Torino*, vols. xxviii.–xxix). Most of the animals recorded belong to species already known from other parts of the Mediterranean region, but a few are new or of special interest. A hundred and thirteen species of birds were obtained, including a new species of jay (Garrulus) and a new species of redbreast (Erithacus). There are two new earthworms (Helodrilus), two new woodlice (Armadillidium), three new locustids, one of which is referred to a new genus, and a new variety of the river crab (*Potamon edule*) of southern Europe. The other groups reported upon are the hymenoptera, fleas, earwigs, scorpions, and the mosses and liverworts (these last in *Annali di Botanica*, vol. xii.).

AN account of work on the control of damping-off disease in plant beds has been recently published in bulletin form (No. 31, University of Wisconsin Agricultural Experiment Station). According to the observations of the author, Mr. James Johnson, the two most common fungi giving rise to the disease are Pythium de Baryianum and Rhizoctonia, and these have been found on seedlings of a large number of different plants, including cress, tobacco, lettuce, tomato, etc. The effect of various cultural conditions, such as moisture, temperature, aeration on the growth and spread of the disease, is discussed, and the results of experiments as to preventive measures are given.

Treatment of infected soils with formalin 1 : 50 has been found efficient in checking the disease, but from the point of cheapness and efficiency steam-heating is recommended. Certain secondary effects, such as the killing of weed seeds and the destruction of insect pests in the soil, and greatly increased size and vigour of plants grown in treated soils, were also noted.

IN a recent Bulletin of the U.S. Weather Bureau the Rev. M. Saderra Masó describes an interesting series of earthquakes which occurred in the sub-province of Benguet (Luzon) in August and September, 1913. They were very numerous (about 350 occurring in little more than a month), as a rule of slight intensity, and, even with the strongest, of very small disturbed area. It is probable that they originated at a very slight depth. As the earthquakes occurred at the close of the rainy season, in a limestone district in which the annual rainfall is about 160 inches, and in which there are frequent subsidences of the ground, the author concludes that the earthquakes are neither tectonic nor volcanic in their origin, but probably due to underground rock-falls and secondary faults.

THE Meteorological Office of Canada has recently issued an interesting monograph, "Canadian Weather Forecasting," as an addendum to "Gales from the Great Lakes to the Maritime Provinces," covering the years 1905–12, prepared by Mr. B. C. Webber, under the superintendence of the director of the Meteorological Service. In a preceding monograph for the period 1874–1904 Mr. Webber suggested some aids to assist the forecast officials, and these have now been supplemented, and the tables show, in addition, the percentages of low-pressure areas causing storms in various months and districts and the directions in which the depressions moved, together with other useful information. November is the most stormy month on the Great Lakes during the season of navigation, but January and February are the stormiest in the Gulf of St. Lawrence and the Maritime Provinces; March is not an unusually stormy month. Within the eight years in question the area of the Canadian weather map has been much enlarged, and knowledge of movements of high- and low-pressure areas has been enhanced by the introduction of a daily meteorological chart of the northern hemisphere since January 1, 1912. It is, however, reluctantly admitted that the advancement of weather forecasting has been more or less disappointing. The author considers that the study of the upper air and of solar physics will eventually undoubtedly assist in solving some of the vexed problems which confront the meteorologist.

THE necessity of bringing modern mathematical concepts within the range of study of comparatively elementary students has led Mr. C. Elliott, of King Edward VII. School, Sheffield, to produce a book of 116 pages, entitled "Models to Illustrate the Foundations of Mathematics" (Edinburgh: Lindsay and Co., 1914, price 2*s.* 6*d.*). It consists of four chapters dealing respectively with the meaning of correspondences, multiplexes, spaces defined as ordered multiplexes, correspondence of operands to functions, and multiple correspondence. Although a selection of classificatory models was exhibited at the 1912 Mathematical Congress, the use of the term "models" in the title of this book may perhaps be rather misleading, for it consists mainly of definitions and explanations, and the nearest approach to models generally consists in mere references to illustrations of classes, like and unlike things, correspondences, and so forth, where these can be exemplified by objects of everyday life. The question as to how far the subject can be understood and appreciated by schoolboys is a very interesting one.

THE first of a series of illustrated articles descriptive of a 300,000-h.p. hydro-electric plant on the Mississippi appears in the *Engineer* for May 1. These works are situated at Keokuk, on the Iowa side of the river, about 130 miles north of the mouth of the Missouri River, and 137 miles from the city of St. Louis. One purpose of the power development is to deliver current in large quantities to distant points by transmission lines up to 200 miles in length, and in August last the supply of current to St. Louis was commenced. The electric light and tramway company of St. Louis has contracted to take 60,000 h.p. for a term of ninety-nine years. The works comprise three main sections. First, a dam 4700 ft. long, extending from the east bank at Hamilton to within a thousand feet of the west bank at Keokuk. Secondly, a power-house, extending downstream from the end of the dam for a length of 1700 ft. Thirdly, a dam extending from the lower end of the power-house to the west bank, forming the fore-bay and having a large single-lift lock for navigation. The total length of monolithic concrete construction is more than two miles. The working head of water available for the machines ranges from 23 to 40 ft.

OUR ASTRONOMICAL COLUMN.

MAY METEORS.—It is hoped that favourable conditions will be experienced for the observation of Coronid meteors in May. Mr. W. F. Denning directs attention to this shower in *Astronomische Nachrichten*, No. 4726. In recent years he found the chief radiant point to be about 246°+30° near ζ Coronæ, and a few degrees west of ρ Herculis. According to his observations in 1903 and 1911, the meteors were white, swift, and usually trainless. The most suitable time for their observation is between May 18 and 26, and the absence of the moon will render the observation more easy.

COMET 1914*a* (KRITZINGER).—The following is the continuation of the ephemeris of comet 1914*a* (Kritzinger) which was given in this column last week, the information being gathered from Prof. H. Kobold's communication to the *Astronomische Nachrichten*, No. 4729:—

12*h.* *M.T. Berlin.*

	R.A. (true) h. m. s.	Dec. (true) ° ′	Mag.
May 7 ...	18 46 9	... +23 29·0	
8 ...	50 57	... 24 25·9	... 8·5
9 ...	55 45	... 25 21·9	
10 ...	19 0 34	... 26 16·7	
11 ...	5 24	... 27 10·4	
12 ...	10 14	... 28 2·8	... 8·4
13 ...	15 4	... 28 53·9	
14 ...	19 19 54	... +29 43·6	

The comet is situated near the boundaries of the four constellations, Hercules, Vulpes, Cygnus, and Lyra.

A CONVENIENT COMPARISON SPECTRUM.—For the study of both terrestrial and celestial spectra, it is useful for many purposes to photograph a comparison spectrum alongside the spectrum under investigation. The spectrum of iron is most generally used as the lines are well distrubuted along the spectrum, are sharp, and their wave-lengths are accurately determined. The iron, however, may not be pure, so several strange lines may appear in the spectrum, and these have to be investigated. Dr. Joseph Lunt, in searching for a convenient means of obtaining the spectrum of cyanogen has incidentally found that the spectrum of lead pencils gives an extremely fine set of lines, very sharp, well distributed along the spectrum, exhibits a remarkable constancy of spectroscopic composition, and consists of lines which are almost without exception present in the solar spectrum, the wavelengths of which have been well determined. The account of this investigation on the spectra of graphites and lead pencils is given in vol. x. of the Annals of the Cape Observatory, part iv., and should be read by all those who work with the spectroscope. A plate reproduces the lead pencil spectrum from λ 4071·91 to λ4742·98. The sharp metallic lines are for the most part due to iron, titanium, vanadium, chromium, and the alkaline earths, barium, strontium, and calcium, while the spectrum shows also the presence of the rarer elements, gallium, scandium, and yttrium, as well as silicon, magnesium, and manganese. The carrier of a lead pencil thus possesses a small portion of the very rare elements gallium and scandium.

REPORT OF HARVARD COLLEGE OBSERVATORY.—The report of the director of the Astronomical Observatory of Harvard College for the year ending September, 1913, gives one a good idea of the great field of work projected and of the large amount of work accomplished during the past months. It is hoped that means will be found to concede to the director's wishes stated in this report by increasing the income of the observatory, for the situation is not very satisfactory when, as Prof. Pickering states, "during the last twenty years the income of the University has more than doubled, while that of the observatory has diminished rather than increased." The report shows, in the first instance, the progress made in the Henry Draper memorial department, the revised Draper Catalogue being the principal work. More than half the sky has been covered, and 100,155 stellar spectra have already been classified. The 11-in. Draper telescope, in the hands of Prof. W. H. Pickering, has produced valuable results, among which may be mentioned the periodic changes in form of the discs of Jupiter's satellites. The work of the Boyden department at the Arequipa Station, of the Blue Hill Meteorological department (recently transferred to Harvard University), etc., are all briefly summarised, and indicate the wide range of activities.

THE SCHILOWSKY GYROSCOPIC TWO-WHEELED MOTOR-CAR.

A LARGE two-wheeled motor-car, constructed from the design of Dr. Schilowsky, a Russian Doctor of Laws, by the Wolseley Tool and Motor Company, Ltd., was given a trial run in London last week. The car is a six-seated car, and it carried six people as it slowly made a circuit of Regent's Park. The gyroscopic mechanism is placed in the cupboard under the middle four seats. This consists of a heavy gyrostat rotating at the moderate speed of 1100 revolutions a minute, and driven by an electric motor of $1\frac{1}{2}$ horse-power. The axis is vertical, and it is mounted in a ring supported on transverse trunnions, so that it may tilt in a fore and aft plane. As the car is necessarily unstable on its two wheels, the gyrostatic ring must also be carried unstably for it to have corrective influence. If, as a ship, the car could have been carried stably, then the gyrostatic ring would also have to be stably mounted. If one is stable and the other unstable then the gyrostat operates in the opposite sense to that intended.

The unstably mounted gyrostat will not maintain the car in its upright position for long, as the precessional oscillations increase in amplitude. Dr. Schilowsky counteracts this by an ingenious piece of mechanism. Driven by worm-gearing from the gyrostat axle are two spur wheels, each just out of gear with a segmental rack, but capable of being brought into gear by a heavy pendulum which feels any tilting of the car away from the dynamical vertical. This is only allowed to engage at such times as the gyrostat ring is approaching the neutral position. During this time the engagement causes a hurrying of the precession and a consequent steadying of the motion. At the moment the neutral position is reached the pinion and rack are disconnected by a snap mechanism reminding one of that used for closing the valves of a Corliss engine. One pendulum controls the engagement when the gyrostatic ring is approaching the neutral position from one side, while the other effects the control on the other side of the neutral position. Either alone might be used, but the two alternate with one another and maintain a more continuous control. It is a curious fact that the controlling mechanism is more easily adjusted so as to maintain the equilibrium of the car when it is turning in the opposite direction to the rotation of the wheel. For turning in the same direction more exact adjustment is necessary. A working model railway on this system has been presented by Dr. Schilowsky to the South Kensington Museum, where it may be seen by anyone interested.

The car weighed three tons, having been designed for running on a rail, while the engine was one of the maker's standard 16-h.p. engines. This was insufficient in power to drive the heavy car, as well as the motor of the flywheel, more than about four miles an hour. At this speed and at rest or moving backwards the car maintained its position with passengers jumping on or off. When a new load was applied to one side the car moved almost imperceptibly so as to raise it and maintain the centre of gravity over the line of support as has already been made familiar by Mr. Brennan with his monorail.

It will be interesting to see how the car behaves when a more powerful engine is fitted and higher speeds are possible. The inventor is, of course, aware of the very great couple, ordinarily resisted by the four-wheel support of the motor-car when ordinary curves and speeds are negotiated together, which he will have to contend with in like circumstances. The demonstration in the Regent's Park did not show that the gyrostatic control then existing would be sufficient for this, but it did show, and that perfectly, that the first step has been successfully accomplished. It may be worth while to add that the bicycle balance is not used, the gyrostatic control being independent of speed or direction of motion.

C. V. BOYS.

RELATIONS BETWEEN THE SPECTRA AND OTHER CHARACTERISTICS OF THE STARS.*

II.

Brightness and Spectral Class.

HAVING thus made a rapid survey of the general field, I shall now ask your attention in greater detail to certain relations which have been the more special objects of my study.

Let us begin with the relations between the spectra and the real brightness of the stars. These have been discussed by many investigators—notably by Kapteyn and Hertzsprung—and many of the facts which will be brought before you are not new; but the observational material here presented is, I believe, much more extensive than has hitherto been assembled. We can only determine the real brightness of a star when we know its distance; but the recent accumulation of direct measures of parallax, and the discovery of several moving clusters of stars the distances of which can be determined, put at our disposal far more extensive data than were available a few years ago.

Fig. 1 shows graphically the results derived from all the direct measures of parallax available in the spring of 1913 (when the diagram was constructed). The spectral class appears as the horizontal coordinate, while the vertical one is the absolute magnitude, according to Kapteyn's definition—that is, the visual magnitude which each star would appear to have if it should be brought up to a standard distance, corresponding to a parallax of 0·1″ (no account being taken of any possible absorption of light in space). The absolute magnitude, −5, at the top of the diagram, corresponds to a luminosity 7500 times that of the sun, the absolute magnitude of which is 4·7. The absolute magnitude 14, at the bottom, corresponds to 1/5000 of the sun's luminosity. The larger dots denote the stars for which the computed probable error of the parallax is less than 42 per cent. of the parallax itself, so that the probable error of the resulting absolute magnitude is less than ±1·0m. This is a fairly tolerant criterion for a "good parallax," and the small dots, representing the results derived from the poor parallaxes, should scarcely be used as a basis for any argument. The solid black dots represent stars the parallaxes of which depend on the mean of two or more determinations; the open circles, those observed but once. In the latter case, only the results of those observers whose work appears to be nearly free from systematic error have been included, and in all cases the observed parallaxes have been corrected for the probable mean parallax of the comparison stars to which they were referred. The large open circles in the upper part of the diagram represent mean results for numerous bright stars of small proper-motion (about 120 altogether) the observed parallaxes of which scarcely exceed their probable errors. In this case the best thing to do is to take means of the observed parallaxes and magnitudes for suitable groups of stars, and then calculate the absolute magnitudes of the typical stars thus defined. These will not exactly

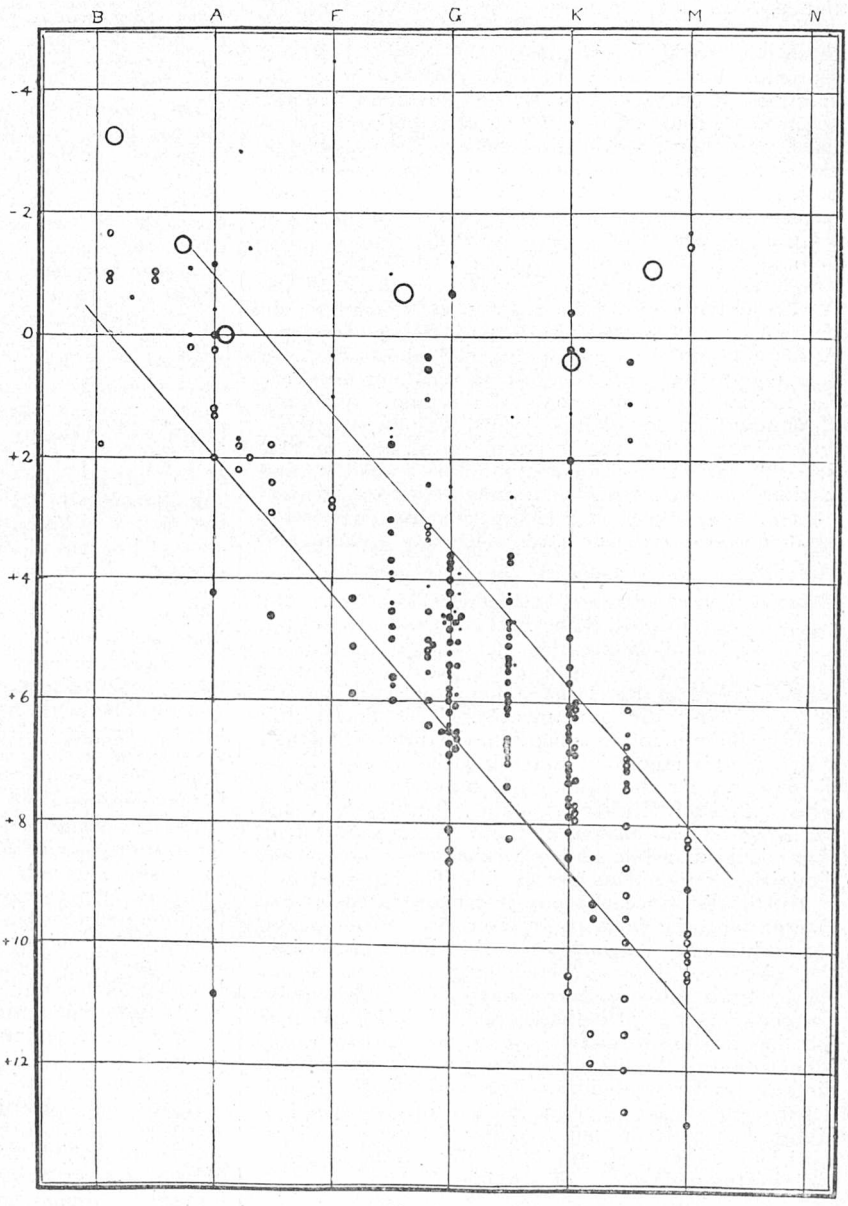


FIG. 1.

* An address delivered before a joint meeting of the Astronomical and Astrophysical Society of America and Section A of the American Association for the Advancement of Science, at Atlanta, Georgia, December 30, 1913, with a few additions, by Prof. H. N. Russell. Continued from p. 230.

correspond to the mean of the individual absolute magnitudes which we could obtain if we knew all the parallaxes exactly, but they are pretty certainly good enough for our purpose.

Upon studying Fig. 1 several things can be observed.

(1) All the white stars, of Classes B and A, are bright, far exceeding the sun; and all the very faint stars—for example, those less than 1/50 as bright as the sun—are red, and of Classes K and M. We may make this statement more specific by saying, as Hertzsprung does,[16] that there is a certain limit of brightness for each spectral class, below which stars of this class are very rare, if they occur at all. Our diagram shows that this limit varies by rather more than two magnitudes from class to class. The single apparent exception is the faint double companion to O_2 Eridani, concerning the parallax and brightness of which there can be no doubt, but the spectrum of which, though apparently of Class A, is rendered very difficult of observation by the proximity of its far brighter primary.

(2) On the other hand, there are many red stars of great brightness, such as Arcturus, Aldebaran, and Antares, and these are as bright, on the average, as the stars of Class A, though probably fainter than those of Class B. Direct measures of parallax are unsuited to furnish even an estimate of the upper limit of brightness to which these stars attain, but it is clear that some stars of all the principal classes must be very bright. The range of actual brightness among the stars of each spectral class therefore increases steadily with increasing redness.

(3) But it is further noteworthy that all the stars of Classes K5 and M which appear on our diagram are either very bright or very faint; there are none comparable with the sun in brightness. We must be very careful here not to be misled by the results of the methods of selection employed by observers of stellar parallax. They have for the most part observed either the stars which appear brightest to the naked eye, or stars of large proper-motion. In the first case, the method of selection gives an enormous preference to stars of great luminosity, and, in the second, to the nearest and most rapidly moving stars, without much regard to their actual brightness. It is not surprising, therefore, that the stars picked out in the first way (and represented by the large circles in Fig. 1) should be much brighter than those picked out by the second method (and represented by the smaller dots). But if we consider the lower half of the diagram alone, in which all the stars have been picked out for proper-motion, we find that there are no very faint stars of Class G, and no relatively bright ones of Class M. As these stars were selected for observation entirely without consideration of their spectra (most of which were then unknown) it seems clear that this difference at least is real, and that there is a real lack of red stars comparable in brightness with the sun, relatively to the number of those 100 times fainter.

The appearance of Fig. 1 therefore suggests the hypothesis that, if we could put on it some thousands of stars instead of the 300 now available, and plot their absolute magnitudes without uncertainty arising from observational error, we would find the points representing them clustered principally close to two lines, one descending sharply along the diagonal, from B to M, the other starting also at B, but running almost horizontally. The individual points, though thickest near the diagonal lines, would scatter above and below it to a vertical distance corresponding to at least two magnitudes, and similarly would be thickest near the horizontal line, but scatter above and below it to a distance which cannot so far be definitely specified, so that there would be two fairly broad bands in which most of the points lay. For Classes A and F these two zones would overlap, while their outliers would still intermingle in Class G, and probably even in Class K. There would, however, be left a triangular space between the two zones, at the right-hand edge of the diagram, where very few (if any) points appeared, and the lower left-hand corner would be still more nearly vacant.

We may express this hypothesis in another form by saying that there are two great classes of stars, one of great brightness (averaging, perhaps, a hundred times as bright as the sun), and varying very little in brightness from one class of spectrum to another; the other of smaller brightness, which falls off very rapidly with increasing redness. These two classes of stars were first noticed by Hertzsprung,[17] who has applied to them the excellent names of *giant* and *dwarf* stars. The two groups, on account of the considerable internal differences in each, are only distinctly separated among the stars of Class K or redder. In Class F they are partially, and in Class A thoroughly, intermingled, while the stars of Class B may be regarded equally well as belonging to either series.

In addition to the stars of directly measured parallax, represented in Fig. 1, we know with high accuracy the distances and real brightness of about 150 stars which are members of the four moving clusters the convergent points of which are known, namely, the Hyades, the Ursa Major group, the 61 Cygni group, and the large group in Scorpius, discovered independently by Kapteyn, Eddington, and Benjamin Boss, the motion of which appears to be almost entirely parallactic. The data for the stars of these four groups are plotted in Fig. 2, on the same system as in Fig. 1. The solid black dots denote the members of the Hyades; the open circles, those of the group in Scorpius; the crosses, the Ursa Major group; and the triangles, the 61 Cygni group. Our lists of the members of each group are probably very nearly complete down to a certain limiting (visual) magnitude, but fail at this point, owing to lack of knowledge regarding the proper motions of the fainter stars. The apparently abrupt termination of the Hyades near the absolute magnitude 7·0, and of the Scorpius group at 1·5, arises from this observational limitation.

The large circles and crosses in the upper part of Fig. 2 represent the absolute magnitudes calculated from the mean parallaxes and magnitudes of the groups of stars investigated by Kapteyn, Campbell, and Boss, concerning which data were given in Table III. The larger circles represent Boss's results, the smaller circles Kapteyn's, and the large crosses Campbell's.

It is evident that the conclusions previously drawn from Fig. 1 are completely corroborated by these new and independent data. Most of the members of these clusters are dwarf stars, and it deserves particular notice that the stars of different clusters, which are presumably of different origin, are similar in absolute magnitude. But there are also a few giant stars, epecially of Class K (among which are the well-known bright stars of this type in the Hyades); and most remarkable of all is Antares, which, though of Class M, shares the proper motion and radial velocity of the adjacent stars of Class B, and is the brightest star in the group, giving out about two thousand times the light of the sun.

[16] *A. N.*, 4422, 1910.

[17] *Zeitschrift für Wissenschaftliche Photographie*, vol. iii., p. 442, 1905.

It is also clear that the naked-eye stars, studied by Boss, Campbell, and Kapteyn, are, for the most part, giants. With this in mind, we are now in a position to explain more fully the differences between the results of these investigators.

All the stars of Class B are giants, and, so far as we may judge from the Scorpius cluster, they do not differ from one another very greatly in absolute brightness. It is therefore natural that the results of all three investigators are in this case fairly similar, though Campbell, in employing stars that averaged brighter to the eye than did the others, has evidently been working with stars that are really brighter. In Class A the giants and dwarfs differ so little, and are so thoroughly intermingled, that the situation is about the same. In Class M, even the nearest and brightest of the dwarf stars are invisible to the naked eye: hence the stars of this class studied by the three investigators are all giants, and once more their results agree.

A number of the dwarf stars of Class K are visible to the naked eye; but these all lie very near us, and have such large proper motions that they are excluded as "abnormal" by both Campbell and Boss. The results of the two agree in indicating that the stars studied by them are typical giants. The few dwarfs, however, have such large parallaxes and proper-motions that their inclusion more than doubles the mean proper-motion, and presumably, also, the mean parallax of the whole, as shown by Kapteyn's figures in Table III. For Class G, the dwarf stars average much brighter, and a much greater number of them is visible to the naked eye. These have large parallaxes and proper-motions, and raise the average for all the stars of this class to greater values than for any other. But Boss's rigorous limitation to small proper-motions weeds them practically all out, leaving giant stars once more. Campbell's less drastic procedure omits only the nearer of the dwarfs (to be precise, those with the larger proper-motions), and his result lies about half-way between the others. In the case of Class F, the dwarf stars are still brighter—intermingling, in fact, with the giants. We can therefore see them farther off, and we get more of them in our catalogues, in proportion to the giants, than in any other class. Their mean parallax is, however, smaller than for the dwarfs of Classes G and K, and hence the mean proper-motion and parallax of all the stars of this class is less than for Class G. Campbell's criterion here excludes very few stars, and even Boss's admits a good many of the remoter and slower moving dwarfs, causing his mean parallax and proper-motion to be considerably greater for this class than for any other.

It should finally be added that Kapteyn's discussion shows that the stars of Class N are exceedingly bright, possibly surpassing any of the other giant stars.

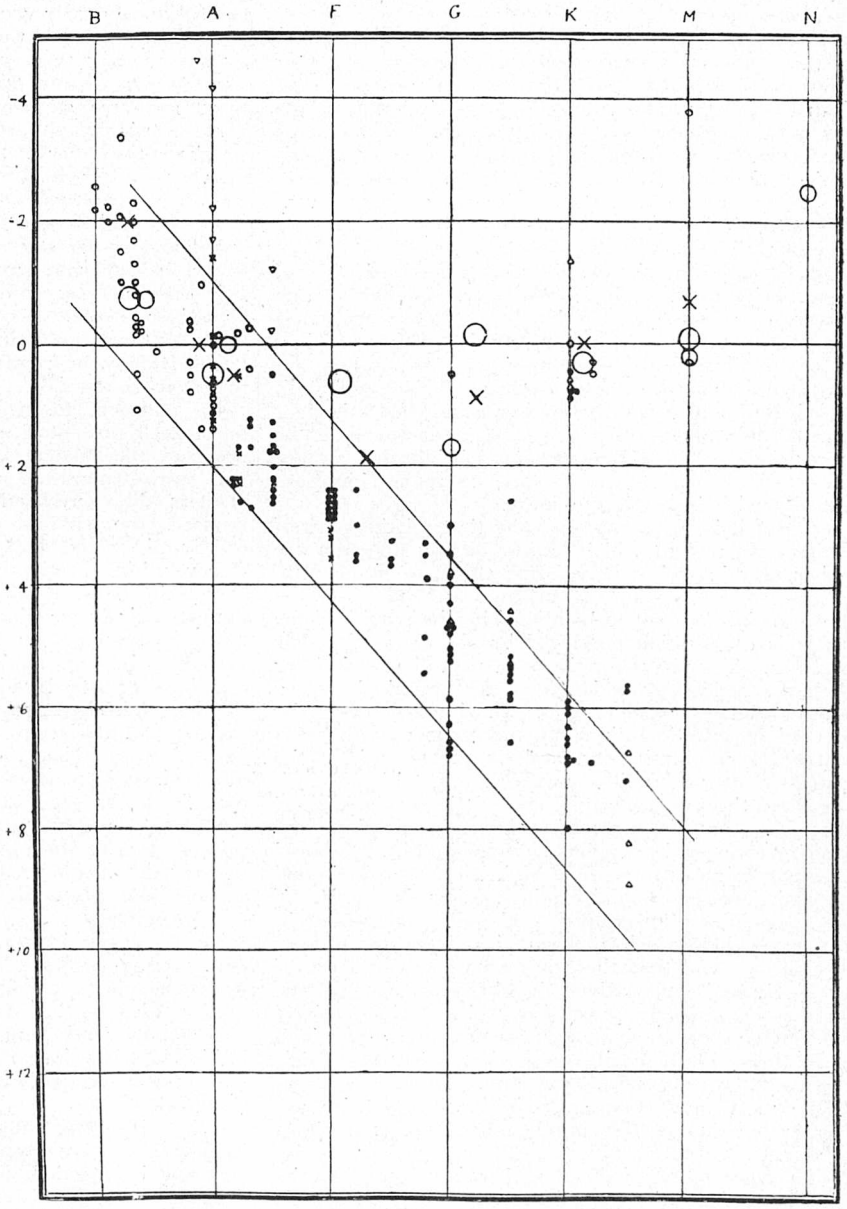


FIG. 2.

We are now in a position to define more precisely the brightness of a typical giant or dwarf star of a given class of spectrum, and also to obtain a measure of the degree of divergence of the individual stars from this typical brightness. Taking first the stars of Class B and the dwarf stars of the other classes,

we find, for the mean absolute magnitudes of all the stars of each class, the following values :—

TABLE V.

Mean Absolute Magnitudes.

Spectrum	Stars of measured parallax No.	Abs. mag.	Formula	O–C m.	Stars in clusters No.	Abs. mag.	Formula	O–C m.
B2	—	—	—	—	21	−1·2	−1·1	−0·1
B8	—	—	—	—	8	+0·3	+0·2	+0·1
Ao	6	+1·4	+1.4	0·0	13	0·5	0 6	−0·1
A4	7	2·5	2·3	+0·2	26	1·7	1·5	+0·2
Fo	—	—	—	—	15	2·4	2·7	−0·3
F1	5	4·2	3·7	+0·5	—	—	—	—
F3	—	—	—	—	7	3·3	3·3	0·0
F5	9	4·3	4·5	−0·2	—	—	—	—
F8	8	5·1	5·2	−0·1	5	4·2	4·4	−0·2
Go	29	5·7	5·6	+0·1	18	5·0	4 8	+0·2
G5	19	5·7	6 6	−0·9	9	5·1	5·8	−0·7
Ko	28	7·1	7·7	−0·6	9	6·4	6·9	−0·5
K4	19	9·2	8·6	+0·6	7	+7·0	+7·7	(−0·7)
Ma	10	+9·9	+9 8	+0·1	—	—	—	—

The rate of decrease of brightness with increasing redness is very nearly the same for the stars with directly measured parallaxes and the stars in clusters, but the latter appear, with remarkable consistency, to be about 0·8m. brighter than the former. This seems at first sight very puzzling, but it is undoubtedly due to the way in which the stars observed for parallax were selected. Most observers, in preparing their working lists, have included mainly those stars which were brighter than a given magnitude and had proper-motions exceeding some definite limit. Of the stars above this limiting magnitude, those of greater actual luminosity will be, on the average, farther away, and have smaller proper-motions, than those of small luminosity, and selection by proper-motion favours the latter. The limitation of our present lists to stars the parallaxes of which have been determined with a probable error not exceeding 42 per cent. of their own amounts, though necessary to diminish the effects of casual errors of observation, works in the same direction, for, among the stars of any given visual magnitude, those of greatest luminosity have the smallest parallaxes, and are least likely to pass the test. The difference shown in our table need not therefore alarm us, but it is clear that the stars in clusters, rather than the others, should be taken as typical of the dwarf stars as a whole. For both sets of stars the absolute magnitude appears to be very nearly a linear function of the spectral class (if B is regarded as 1, A as 2, etc.) The columns headed "formula" in Table V. give the values calculated from the expressions M = 1·4m. + 2·1m. (Sp. − A) for the stars of directly measured parallax, and M = 0·6m. + 2·1m. (Sp. − A) for the stars in clusters. The residuals from these empirical formulæ, for the mean absolute magnitudes of the observed stars of different classes, average ±0·33m. in the first case and ±0·29m. in the second. They appear to be accidental in character, though in some cases (notably in Class G5) the residuals for the stars of the two sets are similar in sign and magnitude. The large negative residuals for Classes K and K5 in the clusters arise from the fact that in the Hyades, which contribute most of these stars, only the brighter ones have had their proper-motions determined, and get into our lists, as is clear from examination of Fig. 2.

Among the dwarf stars, therefore, a typical star of any spectral class is about seven times fainter than one of the preceding class, and seven times brighter than one of the following class.

The giant stars of all the spectral classes appear to be of about the same mean brightness, averaging a little above absolute magnitude zero, that is, about a hundred times as bright as the sun. Since the stars of this series which appear in Fig. 2 have been selected by apparent brightness, which gives a strong preference to those of the greatest luminosity, the average brightness of all the giant stars in a given region of space must be less than this, perhaps considerably so.

By tabulating the residual differences between the absolute magnitudes of the individual dwarf stars and the values given by the formulæ just described, we find that the average difference, regardless of sign, for the stars of measured parallax is ±0·88m. for spectra A to F8, ±1·02m. for spectra G and G5, and ±1·15m. for K and M. For the stars in clusters, the average differences are ±0·70m. for spectra BO to B9, ±0·66m. for A and A5, ±0·56m. for spectra F to F8, and ±0·8om. for G and G5.

These differences are larger for the stars of measured parallax than for the others (probably on account of the greater average uncertainty of the individual parallaxes and spectra in this case), but show no marked systematic variation with the class of spectrum. Their distribution follows very approximately the law of accidental errors, as is shown by Table VI., in which the observed numbers lying between certain limits are compared with those given by this law

TABLE VI.

Distribution of Differences from the Typical Absolute Magnitudes.

Stars with measured parallax Limits m.	Observed	Theory	Stars in clusters Limits m.	Observed	Theory
±0·0 to ±0·8	65	61	±0·0 to ±0·5	59	58
±0·8 to ±1·6	41	44	±0·5 to ±1·0	42	42
±1·6 to ±2·4	21	23	±1·0 to ±1·5	21	24
±2·4 to ±3·2	10	9	±1·5 to ±2·0	10	8
±3·2 to ±4·0	3	3	±2·0 to ±2·5	4	4

The theoretical distribution for the stars in clusters corresponds to a probable error of ±0·61m., and that for the others to one of ±0·94m. Correction for the known influence of uncertainties of the parallaxes and spectra would reduce the latter to about ±0·75m. It appears, therefore, that the absolute magnitude of a dwarf star can be predicted with surprising accuracy from a mere knowledge of its spectrum. Half of all the dwarf stars are not more than twice as bright or as faint as the typical stars of their spectral classes. The corresponding uncertainty in the estimated parallax would be about one-third of its amount.

The parallaxes of the giant stars are so small, in comparison with the errors of even the best present methods of observation, that direct observations are not well adapted to determine to what degree they differ in brightness among themselves. An indirect method of determining this is, however, practicable, among those classes in which all the naked-eye stars are giants, by comparing the parallactic motions of those stars the proper-motions of which at right angles to the direction of the parallactic drift are large and small. A discussion by this method of the typical case of Class M (the details of which will be given elsewhere) shows that, if the distribution of the absolute magnitudes of these stars also follows the "law of errors," the probable error corresponding to it is approximately ±0·6m.—almost exactly the same as has already been found for the dwarf stars. The mean absolute magnitude of all the stars of this class which are visible to the naked eye is −0·5, and that of all the stars in a given region of space is +0·6. This method can scarcely be applied to the naked-eye stars of the other spectral classes (unless some way can be devised for weeding out the dwarf stars from among the giants); but it seems probable

that they do not differ greatly from the stars of Classes B and M as regards the degree of their similarity to one another in brightness With such a probable error of distribution of the absolute magnitudes as has here been derived, the giant and dwarf stars would overlap perceptibly in Class G, be just separated in Class K, and widely so in Class M, as the observational data indicate.

The questions now arise: What differences in their nature or constitution give rise to the differences in brightness between the giant and dwarf stars? and Why should these differences show such a systematic increase with increasing redness or "advancing" spectral type?

We must evidently attack the first of these questions before the second. The absolute magnitude (or the actual luminosity) of a star may be expressed as a function of three physically independent quantities —its mass, its density, and its surface-brightness. Great mass, small density, and high surface-brightness make for high luminosity, and the giant stars must possess at least one of these characteristics in a marked degree, while the dwarf stars must show one or more of the opposite attributes.

A good deal of information is available concerning all these characteristics of the stars. The masses of a considerable number of visual and spectroscopic binaries are known with tolerable accuracy, the densities of a larger number of eclipsing variable stars have recently been worked out, and the recent investigations on stellar temperatures lead directly to estimates of the relative surface brightness of the different spectral classes (subject, of course, to the uncertainty whether the stars really radiate like black bodies, as they are assumed to do). We will take these matters up in order.

First, as regards the masses of the stars, we are confined to the study of binary systems, which may or may not be similar in mass to the other stars. There appears, however, to be no present evidence at all that they are different from the other stars, and in what follows we will assume them to be typical of the stars as a whole.

The most conspicuous thing about those stellar masses which have been determined with any approach to accuracy is their remarkable similarity. While the range in the known luminosities of the stars exceeds a millionfold, and that in the well-determined densities is nearly as great, the range in the masses so far investigated is only about fiftyfold. The greatest known masses are those of the components of the spectroscopic binary and eclipsing variable V Puppis, which equal nineteen times that of the sun; the smallest masses concerning which we have any trustworthy knowledge belong to the faint components of ζ Herculis and Procyon, and are from one-third to one-fourth of the sun's mass. These are exceptional values, and the components of most binary systems are more nearly similar to the sun in mass.

There appears, from the rather scanty evidence at present available, to be some correlation between mass and luminosity. Those stars which are known to be of small mass (say, less than half the sun's) are all considerably fainter than the sun. On the other hand, Ludendorff [18] has shown conclusively that the average mass of the spectroscopic binaries of spectrum B (which are all of very great luminosity) is three times as great as that of the spectroscopic binaries of other spectral types, and may exceed ten times that of the sun. Further evidence in favour of this view is found in the fact that the components of a binary, when equal in brightness, are nearly equal in mass, while in unequal pairs the brighter star is almost (if not quite) always the more massive, but the ratio of the masses very rarely exceeds 3 : 1, even when one component is hundreds of times as bright as the other. Very large masses (such as one hundred times the sun's mass) do not appear, though they would certainly be detected among the spectroscopic binaries if they existed. It is equally remarkable that there is no trustworthy evidence that any visible star has a mass as small as one-tenth that of the sun. The apparent exceptions which may be found in the literature of the subject may be shown to arise from faulty determinations of parallax, arbitrary estimates of quantities unobtainable by observation (such as the ratio of the densities of the two components of Algol), and even numerical mistakes.

It follows from this similarity of mass that we can obtain a very fair estimate of the parallax of any visual binary (called by Doberck the hypothetical parallax) by guessing at its mass, and reversing the familiar relation between mass and parallax. If we assume that the mass of the system is twice that of the sun (about the average value), our hypothetical parallaxes, as the existing evidence shows, will usually be well within 40 per cent. of the truth, and the deduced absolute magnitudes of the components will rarely be more than one magnitude in error. We may thus extend our study of the relation between absolute magnitude and spectrum to all the visual binaries for which orbits have been computed. The hypothetical absolute magnitudes which we will obtain for them will indeed be somewhat in error, owing to the differences in their masses; but, for our present purpose, *the hypothetical values are actually more useful than the true values would be.* This sounds remarkable; but it is easy to show that, if we assume that the brighter components of the systems have all the same mass (say that of the sun), the resulting hypothetical absolute magnitudes will be the actual absolute magnitudes of stars identical in density and surface-brightness with the real stars, but all of the assumed mass. In other words, *the effects of differences of mass among the stars are eliminated from these hypothetical absolute magnitudes,* leaving only those of differences in density and surface-brightness. (This is simply a statement in different form of a theorem which has been known for many years.) It is therefore desirable to extend our study to as many binary stars as possible. The number for which binary orbits have been computed is relatively small, but by a simple statistical process we may include all those pairs which are known to be connected really physically, however slow their relative motion may be.[19]

Consider any pair of stars, of combined mass m times that of the sun, at a distance of r astronomical units, and with a relative velocity of v astronomical units per annum. By gravitational theory, we have

$$v^2r=(2\pi)^2m(2-r/a)=39{\cdot}7m(2-r/a),$$

where a is the semi-major axis of the orbit Now let π be the parallax of the system, s the observed distance in seconds of arc, w the observed relative motion in seconds of arc per annum, and i_1 and i_2 the angles which r and v make with the line of sight. Then $s=r\pi\sin i_1$, $w=v\pi\sin i_2$, and our equation becomes

$$sw^2=39{\cdot}7\pi^3m\sin i_1\sin^2i_2(2-r/a).$$

In the individual case, the last three factors of the second member are unknown, and we are no wiser

[18] *A. N.*, 4520. 1911.

[19] An outline of this method was given by the speaker at the meeting of the Astronomical and Astrophysical Society of America at Ottawa, August 25, 1911, and published in *Science*, N.S., vol. xxxiv., pp. 523–25, October 20, 1911. A similar method was worked out quite independently and almost simultaneously by Hertzsprung, and published in *A. N.*, December 19, 1911 (the date of writing being October 11, 1911).

than at the start; but the average value which their product should have, in a large number of cases, and the percentage of these cases in which it should lie within any given limits, may be computed on the principles of geometrical probability. It is thus found that the formula $\pi^3 = sw^2/14{\cdot}6m$ gives values for the hypothetical parallax the average for a large number of cases of which will be correct, and that, while in individual cases these values will be too large or too small, half of them will be within 19 per cent. of the true values, and the numbers of larger errors will fall off in very nearly the manner corresponding to this probable error. If we compute absolute magnitudes from these parallaxes, their average for all the stars will be a little too bright (since the cases in which the computed parallax comes out too small have more influence than those in which it is too large). This may be allowed for by adding 0·15m. to all the hypothetical magnitudes so computed—an amount almost negligibly small for our present purpose.

We thus obtain a series of hypothetical absolute magnitudes the average for a large number of cases of which will be correct. In 59 per cent. of the individual cases the error arising from the statistical process—that is, from the substitution of a mean value of

$$\sin i_1 \sin^2 i_2 (2 - r/a)$$

for the true value—will affect the deduced magnitude by less than ±0·5m., and in 89 per cent. of all cases the error will not exceed ±1·0m. The approximation is therefore quite sufficient for our purpose. It should, however, be noted that, while the error of the statistical process can never make the computed absolute magnitude of any star too faint by more than 1·5m., it may in rare cases make it too bright by any amount whatever—more than 2·0m. in one case in sixty, more than 3·0m. once in 250 cases, and so on.

We may now proceed to compute hypothetical absolute magnitudes for all the physical pairs which show even a trace of relative motion—including many which are ordinarily described as "fixed," but, on careful study of the observations, show very slow relative change. With the aid of the splendid collection of observational data contained in Burnham's great catalogue and other recent works on double stars, and of many observations of spectra made at Harvard in generous response to requests for information, it has been possible to derive results for more than 550 stars. Assuming that the brighter component of each of these (which is usually the only one of which the spectrum is known) is equal in mass to the sun, estimating that of the fainter component on the basis of the difference of brightness (with the data for the systems in which the mass-ratio is known as a sufficient guide), and proceeding as indicated above, we obtain the data plotted in Fig. 3. The co-ordinates have here the same meaning as in the previous diagrams, and the figure shows at a glance the relations which would exist between the absolute magnitudes and spectra of these 550 stars if all differences of mass were eliminated, leaving only those of density and surface-brightness operative. Binaries for which orbits have been computed are shown by solid dots, and physical pairs, to which the statistical process has been applied, by open circles.

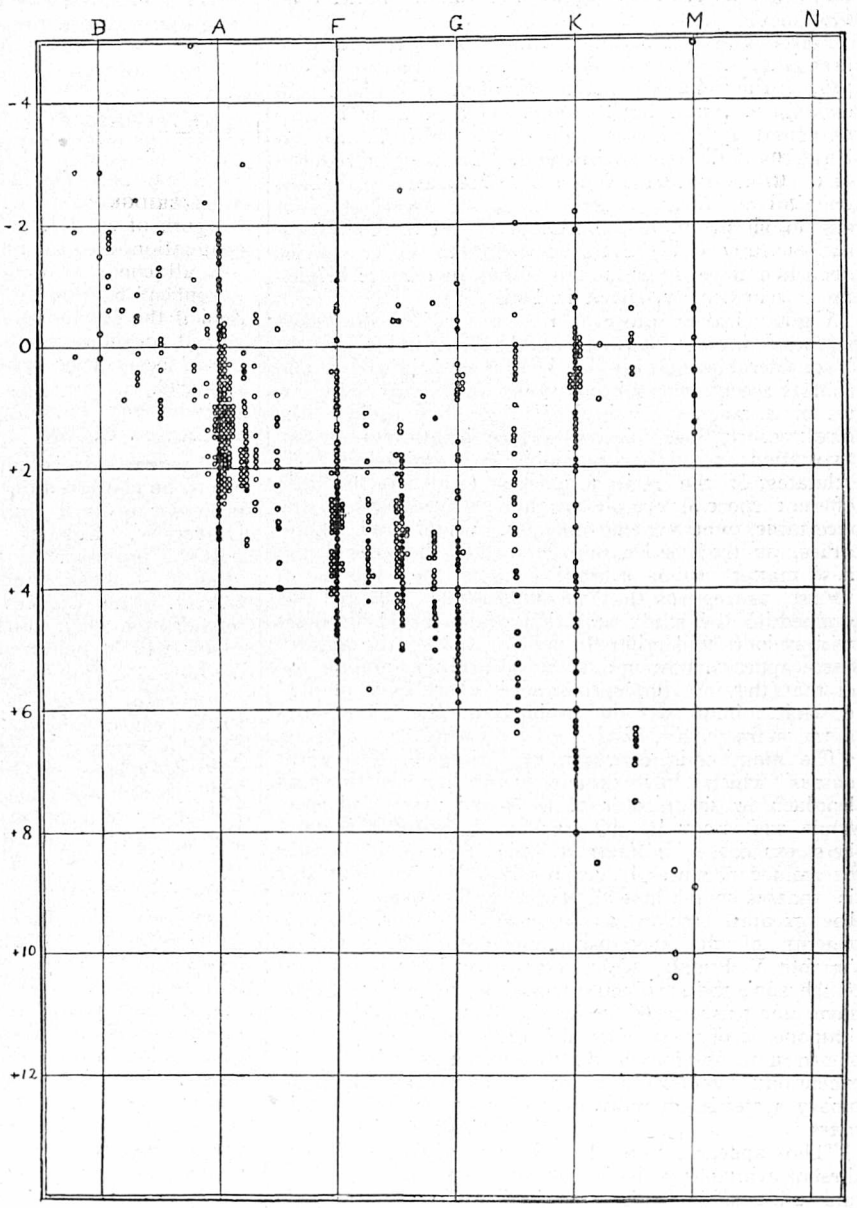


FIG. 3

Our new diagram is strikingly similar in appearance to the previous ones, even in its minor details.

The two series of giant and dwarf stars appear once more; the giants are all of about the same brightness, except that those of Class B are brighter than the rest; the dwarf stars diminish in brightness by about two magnitudes for each spectral class; the two series overlap up to Class G and separate at Class K, and so on. We have clearly come, for the third time, and again from independent data, upon the same phenomena as before; and, with the more extensive observational material, some of the characteristics and relations of the two groups are shown better than ever.

But this new evidence does much more than to confirm that which we have previously considered—it proves that the distinction between the giant and dwarf stars, and the relations between their brightness and spectral types, do not arise (primarily at least) from differences in mass. Even when reduced to equal masses, the giant stars of Class K are about one hundred times as bright as the dwarf stars of similar spectrum, and for Class M the corresponding ratio is fully 1000. Stars belonging to the two series must therefore differ greatly either in surface brightness or in density, if not in both.

There is good physical reason for believing that stars of similar spectrum and colour-index are at least approximately similar in surface brightness, and that the surface brightness falls off rapidly with increasing redness. Indeed, if the stars radiate like black bodies, the relative surface brightness of any two stars should be obtainable by multiplying their relative colour-index by a constant (which is the ratio of the mean effective photographic wave-length to the difference of the mean effective visual and photographic wave-lengths, and lies usually between 3 and 4, its exact value depending upon the systems of visual and photographic magnitude adopted as standards). Such a variation of surface brightness with redness will evidently explain at least the greater part of the change in absolute magnitude among the dwarf stars (as Hertzsprung and others have pointed out), but it makes the problem of the giant stars seem at first sight all the more puzzling.

The solution is, however, very simple. If a giant star of Class K, for example, is one hundred times as bright as a dwarf star of the same mass and spectrum, and is equal to it in surface brightness, it must be of ten times the diameter and 1/1000 of the density of the dwarf star. If, as in Class M, the giant star is one thousand times as bright as the dwarf, it must be less than 1/30,000 as dense as the latter. Among the giant stars in general, the diminishing surface brightness of the redder stars must be compensated for by increasing diameter, and therefore by rapidly decreasing density (since all the stars considered have been reduced to equal mass).

But all this rests on an assumption which, though physically very probable, cannot yet be said to be proved; and its consequences play havoc with certain generally accepted ideas. We will surely be asked, Is the assumption of the existence of stars of such low density a reasonable or probable one? Is there any other evidence that the density of a star of Class G or K may be much less than that of the stars of Classes B and A? Can any other evidence than that derived from the laws of radiation be produced in favour of the rapid decrease of surface brightness with increasing redness?

We can give at once one piece of evidence bearing on the last question. The twelve dwarf stars of Classes K2 to M, shown in Fig. 3, have, when reduced to the sun's mass, a mean absolute magnitude of 7·8—three magnitudes fainter than the sun. If of the sun's surface brightness, they would have to be, on the average, of one-fourth its radius, and their mean density would be sixty-four times that of the sun, or ninety times that of water—which is altogether incredible. A body of the sun's mass and surface brightness, even if as dense as platinum, would only be two magnitudes fainter than the sun, and the excess of faintness of these stars beyond this limit can only be reasonably ascribed to deficiency in surface brightness. For the four stars of spectra K8 and M, the mean absolute magnitude of which, reduced to the sun's mass, is 9·5, the mean surface brightness can at most be one-tenth that of the sun.

(To be continued.)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The office of superintendent of the museum of zoology will shortly become vacant by the resignation of Dr. Doncaster. The stipend at present attached to the office is 200*l.* per annum.

Applications to occupy the University's table in the Zoological Station at Naples, and that in the laboratory of the Marine Biological Association at Plymouth should be addressed to Prof. Langley, The Museums, Cambridge, on or before June 4.

Mr. C. G. Darwin, eldest son of the late Sir George Darwin, has been appointed mathematical lecturer at Christ's College.

GLASGOW.—It is announced that honorary degrees are to be conferred on Dr. Archibald Barr, late regius professor of civil engineering and mechanics in the University, Colonel Sir William B. Leishman, F.R.S., professor of pathology in the Royal Army Medical College, and Sir Ernest H. Shackleton, C.V.O. The degrees will be conferred on Commemoration Day, June 23, when an oration on Lord Lister will be delivered by Sir Hector C. Cameron.

LONDON.—The Page-May Memorial Lectures for the current session will be delivered by Dr. Keith Lucas, whose subject will be "The Conduction of the Nervous Impulse." The course will be held at University College, on Fridays, beginning on May 15. The lectures are open to all internal students of the University of London and to such other persons as are specially admitted. Applications should be addressed to the secretary, University College, London (Gower Street, W.C.).

OXFORD.—Congregation on May 5 passed a statute authorising the establishment of an additional professorship in chemistry, to be called Dr. Lee's Professorship of Chemistry. In the same Congregation the statutes providing for the establishment of Dr. Lee's Professorships of Anatomy and Experimental Philosophy, in place of the existing Lee's Readerships, passed their first stage. Should these statutes be finally approved, the University will be relieved of its present contribution of 1470*l.* towards the stipends of the professors of human anatomy and experimental philosophy, and will gain an additional professor of chemistry, the consequent charges being borne in all these cases by Christ Church.

The Halley Lecture for 1914 will be delivered by Colonel C. F. Close, director of the Ordnance Survey, at the Examination Schools at 8.30 p.m. on May 20. Subject, "The Geodesy of the United Kingdom."

The celebration of the seven hundredth anniversary of the birth of Roger Bacon will be held on Wednesday, June 10.

BROWN UNIVERSITY, Rhode Island, is to receive a visit in November next from Prof. W. H. Bragg,

of Leeds University, who will deliver a course of four lectures on "X-Rays and Crystals."

DR. R. S. ROGERS, a graduate of Edinburgh University, has been appointed lecturer on forensic medicine in the University of Adelaide, and Dr. Swift succeeds Dr. W. T. Hayward as lecturer on clinical medicine in the same University.

THE committee of Livingstone College have decided to appoint Dr. L. E. Wigram to succeed Dr. C. F. Harford as principal of Livingstone College when the latter resigns his post at the end of July. Dr. Wigram was educated at Harrow School, Trinity College, Cambridge, and St. Thomas's Hospital, and he is a graduate in medicine and arts of the University of Cambridge. He was formerly a medical missionary at Peshawar, on the north-west frontier of India, under the Church Missionary Society.

IN the House of Commons on Monday, the Chancellor of the Exchequer explained his Budget proposals. The education grant is to be reconstituted on the principle of making a distinction between the richer and the poorer areas, and between the areas that spend much and those that spend little on education. The increased cost to the Exchequer of the education grant will be 2,750,000*l.*, but this year the grant will be confined to the necessitous school areas. The Government is to contribute one-half of the cost of the feeding of hungry school children, and also to make grants for physical training, open-air schools, maternity centres, and technical, secondary, and higher education. Referring to these grants, Mr. Lloyd George said:—"The grants for technical, secondary, and higher education are to make it more accessible to the masses of the children, and to extend its sphere of influence where children show any aptitude to take advantage of it. We compare very unfavourably with Germany and the United States of America in this respect. There there is adequate provision for technical training, secondary and higher training for every child who shows any special gift for taking advantage of it, and I consider that this fact is a greater menace to our trade than any arrangements of tariffs. We propose that there should be a very substantial grant for this purpose which will include a grant for pensions for secondary-school teachers in order to attract the best men to that most important profession. There will be a grant for the special training of teachers already in schools in subjects specially appropriate to rural areas, manual instruction, cookery, physical exercise, and commercial subjects. The total cost for the first year will be 560,000*l.* for these grants, and 282,000*l.* for the other grants which I mentioned. That will be for the first full year, and will be for England and Wales." There will be a special grant of 750,000*l.* for public health purposes in connection with tuberculosis, nursing, and pathological laboratories. Upon the subject of laboratories, Mr. Lloyd George said:—"Another deficiency has been exposed in our health service by the operation of the Insurance Act. There is no provision for the scientific diagnosis of disease. In Germany, in almost every town, and I think in France, you have pathological laboratories which are of enormous assistance to doctors in ascertaining the real character of a disease when they are in any doubt upon the subject. There are a few boroughs in the United Kingdom where something has been done—even in London—but we propose to make a grant for the purpose of aiding the local authorities to set up these laboratories throughout the United Kingdom."

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, April 30.—Sir William Crookes, O.M., president, in the chair.—Prof. B. **Moore**: The presence of inorganic iron compounds in the chloroplasts of the green cells of plants, considered in relationship to natural photo-synthesis and the origin of life.—Dr. J. C. **Willis**: The lack of adaptation in the Tristichaceæ and Podostemaceæ.—R. P. **Gregory**: The genetics of tetraploid plants in *Primula sinensis*. The paper describes results of experiments with two giant races of *Primula sinensis*, which have been shown to be in the tetraploid condition—that is, the plants have $4x$ (48) chromosomes in the somatic cells and $2x$ (24) chromosomes in the gametic cells, whereas in the ordinary (diploid) races of the species the numbers are $2x$ (24) and x (12) respectively. The result of most general interest is the discovery that reduplication of chromosomes has been accompanied by reduplication of series of factors, so that, whereas in the diploid zygote each factor is represented twice, AA; in the tetraploid zygote it is represented four times, AAAA; and there are three distinct hybrid types, namely, AAAa, AAaa, and Aaaa. The reduplication is made manifest by the occurrence of F2 ratios in the form 15D : 1R, when in the diploid races the ratio is 3D : 1R. This result recalls those obtained by Nilsson-Ehle in oats and wheat, and by East in maize, but in the tetraploid Primulas the reduplication affects not merely the factors for isolated characters, but all the factors which it has been possible to study.—J. A. **Gunn**: The action of certain drugs on the isolated human uterus. It has been found that the involuntary contractile tissues (such as the heart, intestine, and uterus) of *mammals* can be kept exsected in Locke's solution at ordinary room temperatures for many hours, while still retaining the power of executing normal rhythmic movements when subsequently placed, under the proper conditions, in oxygenated Locke's solution at body temperature. With this knowledge, it is possible, without difficulty, to perform experiments on certain isolated human tissues, removed in the course of surgical operations; and those experiments can be made under similar conditions to, and therefore entirely comparable with, experiments made on corresponding tissues of those mammals ordinarily used for investigation. In this paper this method of investigation has first been utilised to determine the response of the isolated human uterus to certain drugs.—D. J. **Lloyd**: The influence of osmotic pressure upon the regeneration of *Gunda ulvae*. *G. ulvae* is capable of living indefinitely in water having an osmotic pressure of more than 2 and less than 33 atmospheres. The rate of regeneration of the posterior end in *G. ulvae* depends on the osmotic pressure of the medium. This osmotic pressure has an optimum value for regeneration at 18 atmospheres, *i.e.* just below that of sea-water, and limiting values at 5 and 33·5 atmospheres. Restoration of lost parts in *G. ulvae* is brought about entirely by the undifferentiated parenchyma cells which migrate to the region of the wound and build up the lost parts.—Surg.-Gen. Sir D. **Bruce**, Major A. E. **Hamerton**, Capt. D. P. **Watson**, and Lady **Bruce**: (*a*) *Glossina brevipalpis* as a carrier of trypanosome disease in Nyasaland. (*b*) Trypanosome diseases of domestic animals in Nyasaland. *Trypanosoma pecorum*. Part iii.—Development in *Glossina morsitans*.—H. E. **Armstrong** and H. W. **Gosney**: Studies on enzyme action. XXII.—Lipase. (IV.).—The correlation of synthetic and hydrolytic activity.

Zoological Society, April 21.—Dr. Henry Woodward, vice-president, in the chair.—Surgeon J. C. **Thompson**: Further contributions to the anatomy of the Ophidia.—Rev. T. R. R. **Stebbing**: Crustacea from the Falkland Islands. At intervals during a period of some fifteen years Mr. Rupert Vallentin has used prolonged opportunities for collecting, among other things, the crustacean fauna of the Falkland Islands. An initial report on this subject was made to the society in the year 1900. In January of the present year Dr. Thomas Scott, in the "Annals and Magazine of Natural History," has discussed some of the Copepoda. The contribution now offered has to do chiefly with the Malacostraca. Five new species are proposed.—J. S. **Huxley**: The courtship of the great crested grebe; with an addition to the theory of sexual selection.—S. **Hirst**: The Arachnida (other than spiders) and Myriopoda obtained by the British Ornithologists' Union and Wollaston Expeditions to Dutch New Guinea. The collection is only a small one, but contains two new species of Acari parasitic on mammals and three new species of millipedes. A new species of parasitic mite collected by Prof. F. Forster on various mammals in German New Guinea is also described.—Major J. Stevenson **Hamilton**: The coloration of the African hunting-dog (*Lycaon pictus*).—C. Tate **Regan**: Note on *Aristeus goldiei*, Macleay, and on some other fishes from New Guinea.—Miss A. **Carlsson**: Two species of fossil Carnivora, from the Phosphorites of Quercy, contained in the collections of the Zootomical Institute at Stockholm.

Challenger Society, April 29.—Prof. E. W. MacBride in the chair.—Prof. E. W. **MacBride**: Conditions of cross-fertilisation in the sea. The factors hindering crossing between different species of Echinoderms were discussed.—C. Tate **Regan**: The distribution of antarctic fishes. It was pointed out that the distribution of coast fishes south of the tropics calls for the recognition of three zones—south temperate, subantarctic, and antarctic. The subantarctic zone includes the Magellan and Antipodes districts; the antarctic zone the Glacial and Kerguelen districts. Nearly all the antarctic fishes are Nototheniiformes, and nearly all the genera and species are peculiar to the zone; in the subantarctic zone Nototheniiformes are present, but there is also a number of south temperate types.

DUBLIN.

Royal Irish Academy, April 27.—Rev. J. P. Mahaffy, president, in the chair.—Rev. Canon **Lett**: A census catalogue of the mosses of Ireland. Part i. This paper gives a short account of all deceased botanists who have paid any attention to the mosses of Ireland, together with a note of all known publications on the subject, from the Rev. John Ray, whose synopsis (1690) is the earliest work in which Irish mosses are mentioned, down to the present day. The list given by the writer contains the names of 636 mosses indigenous to Ireland, and with each is given the first known and the latest records, together with the date and name of the collection.—W. D. **Haigh**: The Carboniferous volcanoes of Philipstown, in King's County. This paper deals with the small volcanic district of Croghan Hill, north of Philipstown, in King's County. In an area of about four square miles a number of volcanic necks breaks through the Carboniferous Limestone. The ash is interbedded with the limestone at and above the cherty zone which separates the Lower from the Middle Limestone. The volcanic activity was thus contemporaneous with the major outbursts in the Limerick district. The latter portion of the paper deals with the petrography of the igneous rocks, which consist chiefly of dolerites and basalts passing into the more basic variety, limburgite. Glomero-porphyritic structure is a common feature of these intrusive rocks.—A. C. **Forbes**: Tree growth (in connection with the Clare Island Survey). Although no plant worthy of the name of tree now exists on Clare Island, abundance of scrub, consisting of oak, birch, mountain ash, holly, hazel, willow, etc., occurs on the east side of the island, suggesting that at no very distant date woodland was more or less general both over Clare Island and the adjacent islands and mainland. Tree remains in the bogs show that pine and birch were originally common on the lower parts of the island, followed at a later date by oak, which is found under mountain peat up to an altitude of 400 ft. The disappearance of this woodland was primarily due to a lowering of the summer temperatures, and an increase of wind off the sea, probably brought about by a higher sea-level in recent times. The original forest flora of the island undoubtedly dates back to a time when a connection with the mainland existed on the south-east, which was probably not interrupted until oak, hazel, and other species had established themselves, and suppressed or took the place of the pine of an earlier period. The most remarkable omissions from the present forest flora of the island are ash and elder, the latter being not only common on the mainland, but difficult to eradicate from grazed or uncultivated land.—G. P. **Farran**: Tunicata and Hemichorda (in connection with the Clare Island Survey). The paper summarised the published records of the group, together with some additional records added in the course of the Clare Island Survey.

PARIS.

Academy of Sciences, April 27.—M. P. Appell in the chair.—The **President** announced the death of Prof. Suess, foreign associate.—H. **Deslandres**: Experimental research of a solar electrical field. Stark has recognised a new effect of the electric field on the light emitted by the canal rays; the bearing of the Stark effect on the study of the solar radiations is fully discussed.—Fred **Wallerant**: The mobility of the molecules in a solid crystal. A crystal of potassium nitrate is fused between two glass plates and allowed to solidify. It is now heated to a temperature well below its melting point, and slightly compressed by pressure at one point of the plate. New crystals appear which grow at the expense of the original crystal, and there is no relation between the orientations of the new and the old crystals. From this the author is led to modify his views on the polymorphism of camphor, which he now holds to be trimorphic and not quadrimorphic.—F. **Becke** was elected a correspondant for the section of mineralogy in the place of the late M. Rosenbusch.—Henri **Chrétien**: A mirror astrolabe. The prism of the ordinary instrument is replaced by two mirrors placed at an angle of 60°, one being fully silvered and the other half silvered. The arrangement possesses the following advantages: homocentricity of the two rays, increase of power of definition, possibility of constructing large astrolabes cheaply, and the suppression of the difficulties arising from the want of homogeneity of the glass of the prisms.—J. **Clairin**: Certain systems of partial differential equations of the second order with two independent variables.—W. **Blaschke**: New evaluation of distances in functional space.—Marcel **Riesz**: An interpolation formula for the differential of a trigonometrical polynomial.—Bertrand **Gambier**: The surfaces susceptible of being formed in several different ways by the displacement of an invariable curve.—Louis **Roy**: The motion in three dimensions of indefinite viscous media.—F. **Jager**: The application of the method of Ritz to certain problems of mathematical physics, and in particular to

the tides.—Léon and Eugène **Bloch**: A new absorption spectrum of oxygen in the extreme ultra-violet. The absorption of air in the extreme ultra-violet commences at a wave-length of 1957, and is shown by a spectrum of regular bands, most probably belonging to oxygen. It is shown that these bands are due to absorption and not to fluorescence.—Thadée **Peczalski**: The differential scale of temperatures.—André **Léauté**: The propagation of surges along a heterogeneous electric line.—Jean **Perrin**: The osmotic compressibility of emulsions considered as fluids with visible molecules. In a previous communication it has been shown that the gas laws apply to dilute emulsions composed of particles of the same magnitude. In the present paper this conception is applied to strong emulsions, making use of Van der Waals equation.—René **Constantin**: The experimental study of the osmotic compressibility of emulsions. The experimental work of the preceding paper. The work was done with uniform spherical grains of radius 0·33 μ. Instantaneous photographs were taken of a column of emulsion 3 μ to 5 μ thick, with a horizontal microscope, sufficient time, three to four days, having been allowed for a state of equilibrium. Up to a certain concentration the fluid follows the law of Van der Waals, but above 2·4 per cent. the internal pressure diminishes, corresponding to a repulsive action between the grains.—A. **Portevin**: Re-heating and annealing after tempering of the alloys of copper and tin and copper and zinc.—Georges **Baume**: Remarks on the mechanism of the chemical reaction.—Auguste **Conduché**: The action of chloroform on metallic sulphates. Method of preparation of anhydrous chlorides. At temperatures above 300° C. chloroform vapour converts the sulphates of various metals into the anhydrous chloride. The reaction with copper sulphate at 300° C. gives pure cupric chloride; other metals require a higher temperature.—Georges **Tanret**: An alkaloid extracted from *Galega officinalis*. The alkaloid is called galigine, and has the composition $C_6H_{13}N_3$. The base is crystalline, and gives crystallised salts. M. **Picon**: The preparation of pure butine. Pure butine (ethylacetylene) has been prepared by the action of ethyl iodide upon sodium acetylide in liquid ammonia at a temperature of −40° C. It was purified by fractional distillation, boils at 8·3°, and melts at −137° C. Its density at 11° C. was found to be 2·47, as against 2·41 theoretical.—M. **Lespieau**: Some derivatives of octadiine-2 : 6-diol-1 : 8. The addition products with bromine, iodine, and hydrogen are described. Hydrogen in the presence of platinum black gives a mixture of the saturated glycol and primary octyl alcohol.—E. **Léger**: The optical isomerides of homonataloin and of nataloin and their reciprocal transformations.—J. L. **Vidal**: Cultural experiments on the vine.—Jacob **Eriksson**: Rust in the seeds of cereals.—R. **Marcille**: The nitrogenous materials of grape must. Both fixed organic nitrogen and volatile ammoniacal or amino-nitrogen are present in relative and absolute proportions which are extremely variable. The quantities are sufficient to ensure regularity in the fermentation.—E. **Maurel**: The influence of climate and season on food requirements. The amount of food required becomes less as the external temperature rises, on account of the smaller heat losses by the skin.—Etienne **Rabaud**: Researches on telegony. From experiments on mice the author is inclined to conclude that telegony is a purely imaginary phenomenon.—Fred **Vlès**: Remarks on the spectral structure of hæmoglobin substances. There are indications that the bands given by this class of substances can be represented by a series similar to that shown by Deslandres to hold for the nitrogen bands.—M. **Vasticar**: The internal auditive region of Corti's organ.—O. **Laurent**: Nervous accidents produced at a distance by projectiles used in war. A discussion of the possibility of nervous diseases being produced by shock without actual wounds by the projectile.—Gabriel **Bertrand**: Silver as a possible stimulant of growth in *Aspergillus niger*. In connection with the effects of traces of zinc and others metals on the growth of moulds, the theory of toxic stimulation has been put forward. Silver salts are known to exert a poisonous action on moulds, and experiments are here described to see if there is a critical concentration at which silver salts exert a stimulating effect on the growth. At no concentration was a stimulating effect observed, and the author contends that the theory of toxic stimulation is improbable.—M. **Javillier**: The utility of zinc for the growth of *Aspergillus niger*, cultivated in deep media. It has been alleged that when this mould is cultivated in deep instead of in shallow layers the favourable effect of zinc vanishes. Experiments are described by the author proving that this is not the case.—Em. **Bourquelot** and M. **Bridel**: The biochemical synthesis of the α-monoglucoside of glycol, by the aid of α-glucosidase. Starting with a solution of *d*-glucose, glycol, and an aqueous extract of low yeast, only the monoglucoside was obtained. Its purification and properties are given in detail.—Charles **Jacob** and Paul **Fallot**: The geology of Montsech, in Catalonia.—F. **Roman**: The Rhinoceridæ of the Mainz basin.

BOOKS RECEIVED.

The Science Reports of the Tôhoku Imperial University, Sendai, Japan. Second series. (Geology.) Vol i., No. 4. Vol. i., No. 5. (Sendai, Japan: Z. P. Maruya and Co., Ltd.)

Conseil Permanent International pour l'Exploration de la Mer. Rapports et Procès-Verbaux des Réunions. Vol. xx. Rapports. Pp. iv+228 Bulletin Statistique des Pêches Maritimes des Pays du Nord de l'Europe. Vol. vii. Pour l'Année 1910. (Copenhague: F. Host et Fils.)

New Zealand. Department of Mines. Geological Survey Branch. Bulletin No. 16 (new series). The Geology of the Aroka Subdivision, Hauraki, Auckland. By J. Henderson, assisted by J. A. Bartrum. Pp. vii+127+plates. (Wellington: J. Mackay.)

Canada. Department of Mines. Geological Survey Guide Books. No. 1 (two parts), Nos. 2, 3, 4, 5, 8 (three parts), 9 and 10. (Ottawa: Government Printing Bureau.)

The Principles of Inorganic Chemistry. By W. Ostwald. Translated by Prof. A. Findlay. Fourth edition. Pp. xxxiii+836. (London: Macmillan and Co., Ltd.) 18*s*. net.

Bulletin of the Argentine Meteorological Office. No. 2. First part. The Laws of the Evaporation of Water from Pans, Reservoirs and Lakes, Sand, Soils, and Plants. By Prof. F. H. Bigelow. Pp. 147. No. 3. The Thermodynamics of the Circulation and the Radiation of the Earth's Atmosphere. By Prof. F. H. Bigelow. Pp. 106. (Buenos Aires.)

Elementary Theory of Equations. By Prof. L. E. Dickson. Pp. v+184. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.) 7*s*. 6*d*. net.

Cape Astrographic Zones. Vol i. Commenced under the direction of Sir David Gill. Completed and prepared for press under the supervision of S. S. Hough. Pp. li+430. (London: H.M.S.O.; Wyman and Sons, Ltd.) 15*s*.

Manual of the New Zealand Mollusca. By H. Suter. Pp. xxiii+1120. (Wellington, N.Z.: J. Mackay.)

Grosse Biologen. By Prof. W. May. Pp. vi+201+plates. (Leipzig and Berlin: B. G. Teubner.) 3 marks.

Das Elisabeth Linné-Phänomen. By Prof. F. A. W. Thomas. Pp. 53. (Jena: G. Fischer.) 1.50 marks.

Field-Studies of Some Rarer British Birds. By J. Walpole-Bond. Pp. x+305. (London: Witherby and Co.) 7*s*. 6*d*. net.

Wild Flowers as They Grow, Photographed in Colour Direct from Nature. By H. E. Corke, with descriptive text by G. C. Nuttall. Seventh series. Pp. viii+204+plates. (London: Cassell and Co., Ltd.) 5*s*. net.

The English Year. Spring. By A. B. Thomas and A. K. Collett. Pp. ix+334+plates. (London and Edinburgh: T. C. and E. C. Jack.) 10*s*. 6*d*. net.

People's Books:—Bacteriology. By Dr. W. E. C. Dickson. Pp. 95. Anglo-Catholicism. By A. E. M. Foster. Pp. 94. Robert Louis Stevenson. By R. Masson. Pp. 94. Canada. By F. Fairford. Pp. 94. Tolstoy. By L. Winstanley. Pp. 96. Greek Literature. By H. J. W. Tillyard. Pp. 92. (London and Edinburgh: T. C. and E. C. Jack.) 6*d*. net each.

Telegraphy. By the late Sir W. H. Preece. New edition. Revised and partly re-written by W. L. Preece. Pp. x+422. (London: Longmans and Co.) 7*s*. 6*d*. net.

Nucleic Acids. By Prof. W. Jones. Pp. viii+118. (London: Longmans and Co.) 3*s*. 6*d*. net.

DIARY OF SOCIETIES.

THURSDAY, MAY 7.

ROYAL SOCIETY, at 4.—Election of Fellows.—At 4.30.—(1) Some Calculations in Illustration of Fourier's Theorem; (2) The Theory of Long Waves and Bores: Lord Rayleigh.—Protection from Lightning and the Range of Protection afforded by Lightning Rods: Sir J. Larmor and J. S. B. Larmor.—Newcomb's Method of Investigating Periodicities and its Application to Brückner's Weather Cycle: Prof. A. Schuster.—The Flow in Metals subjected to Large Constant Stresses: E. N. da C. Andrade.—Eddy Motion in the Atmosphere: G. I. Taylor.—The Properties of Magnetically-shielded Iron as Affected by Temperature: Prof. E. Wilson.

ROYAL INSTITUTION, at 3.—The Last Chapter of Greek Philosophy: Plotinus as Philosopher, Religious Teacher and Mystic: The Very Rev. W. R. Inge.

ROYAL SOCIETY OF ARTS, at 4.30.—The Punjab Canal Colonies: Sir J. M. Douie.

CHILD STUDY SOCIETY, at 7.30.—Education in Early Childhood before School-Age: Miss E. A. Parish and Dr. W. P. Sheppard.

LINNEAN SOCIETY, at 8.—The Botany of the Utakwa Expedition in Dutch New Guinea: H. N. Ridley and Others.—The Genus Lernæodiscus, F. Müller: G. Smith.—The Botanic Gardens at Sibpur (Calcutta), and the Government Cinchona Plantations: Major Gage.—A New Natural Order of Flowering Plants: Tristichaceæ: Dr. I. C. Willis.—The Forced or Cultural Production of Free, Spherical Pearls; a Preliminary Note on a New Method: J. Hornell.—Some Terrestrial Isopoda from New Zealand and Tasmania; with the Description of a New Genus, Notoniscus: Prof. C. Chilton.

FRIDAY, MAY 8.

MALACOLOGICAL SOCIETY, at 8.—Description of a New Helicoid from the Red Crag, Ramsholt: B. B. Woodward and A. S. Kennard.—The Radula of British Helicids. IV.: Rev. E. W. Bowell.—(1) Five New Species of Melania from Yunnan, Java, and the Tsushima Islands; (2) Description a New Species of Strophocheilus, from Peru: H. C. Fulton.

ALCHEMICAL SOCIETY, at 8.15.—Some Mystical Aspects of Alchemy: Dr. E. Severn.

PHYSICAL SOCIETY, at 8.—A Graphic Treatment of the Rainbow and Cusped Wave-fronts: W. R. Bower.—Gyrostatic Devices for the Control of Moving Bodies: Dr. J. G. Gray.

ROYAL ASTRONOMICAL SOCIETY, at 5.—Baxendell's Observations of Variable Stars, III: U Cygni, R Delphini, S Delphini, T Delphini. Edited by H. H. Turner and Mary A. Blagg.—The Resolution of a Compound Periodic Function into Simple Periodic Functions; J. B. Dale.—The Periodogram Analysis of the Variations of SS Cygni: D. Gibb.—A System of Photographic Magnitudes for Southern Stars: J. Halm.—Note on the Double Star OΣ 137: W. S. Franks.—*Probable Paper:* The Nebular Line λ3729: J. W. Nicholson.

SATURDAY, MAY 9.

ROYAL INSTITUTION, at 3.—Bird Migration: Prof. C. J. Patten.

MONDAY, MAY 11.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—The Condition and Prospects of the Panama Canal: Dr. Vaughan Cornish.

ROYAL SOCIETY OF ARTS, at 8.—Some Recent Developments in the Ceramic Industry: W. Burton.

SOCIETY OF ENGINEERS, at 7.30.—Notes on the Water Supply of Greater New York: W. T. Taylor.

ROYAL INSTITUTION, at 3.—The Last Chapter of Greek Philosophy: Plotinus as Philosopher, Religious Teacher and Mystic: The Very Rev. W. R. Inge.

TUESDAY, MAY 12.

ROYAL INSTITUTION, at 3.—The Present State of Evolutionary Theory Prof. W. Bateson.

ROYAL SOCIETY OF ARTS, at 4.30.—The Singing of Songs: Old and New I.: Folk Songs: H. Plunket Greene.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Colour Blindness and Race: Dr. W. H. R. Rivers.—Standing Stones and Stone Circles in Yorkshire: A. L. Lewis.

WEDNESDAY, MAY 13.

ROYAL SOCIETY OF ARTS, at 8.—Glass Painting in Medieval and Renaissance Times: J. A. Knowles.

GEOLOGICAL SOCIETY, at 8.—The Scandinavian Drift of the Durham Coast, and the General Glaciology of South-East Durham: C. T. Trechmann.—The Relationship of the Vredefort Granite to the Witwatersrand System: F. W. Penny.

THURSDAY, MAY 14.

ROYAL SOCIETY, at 4.30.—*Probable Papers:* The Various Inclinations of the Electrical Axis of the Human Heart. IA.: The Normal Heart. Effects of Respiration: Dr. A. D. Waller.—Fossil Plants showing Structure from the Base of the Waverley Shale of Kentcky: Dr. D. H. Scott and Prof. E. C. Jeffrey.—The Controlling Influence of Carbon Dioxide in the Maturation, Dormancy, and Germination of Seeds. II.: Franklin Kidd.—The Cultivation of Human Tumour Tissue *in vitro*: D. Thomson and G. J. Thomson.—The Nutritive Conditions Determining the Growth of Certain Freshwater and Soil Protista: H. G. Thornton and G. Smith.

ROYAL INSTITUTION, at 3.—Identity of Laws in General and Biological Chemistry: Prof. Svante Arrhenius.

CONCRETE INSTITUTE, at 7.30.—Sand and Coarse Material and Proportioning Concrete: J. A. Davenport and Prof. S. W. Perrott.

SOCIETY OF DYERS AND COLOURISTS, at 8.—Notes on the Chemistry of Starch and its Transformations: W. A. Davis.—The Analysis of Malt Extracts: W. P. Dreaper.—Temperature and Concentration as Affecting Hydration and Soda Absorption during the Process of Formation of Cellulose Monofils: Clayton Beadle and H. P. Stevens.

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