THURSDAY, APRIL 20, 1893.

THE NEW UNIVERSITY FOR LONDON.

THE long procession of witnesses which for months past has been defiling before the "Gresham University Commission" has at length come to an end. The Commissioners are now, we suppose, engaged in constructing a scheme for the constitution of the University. Their manner of performing the first portion of their task has been open to criticism. More may be heard hereafter of the extraordinary refusal to furnish the witnesses with copies of their own evidence, and of the still more remarkable fact that, though the majority were denied copies of what they themselves had said, exceptions were made in the case of certain favoured persons who were allowed to see and to contradict the evidence of others.

While the Commission has been sitting several schemes for the constitution of the new University have been proposed. In spite of certain important differences there is one most important point on which they are generally in accord. It is not too much to say that—with no more exceptions than are necessary to prove the rule—every one interested in the future development of the higher education in London agrees that there should be but one university in the metropolis, and that it should not (as was proposed in the discredited Gresham scheme) be a loose federation of competing colleges. It cannot be too strongly urged that the object of a university is the promotion and the diffusion of learning, not the aggrandisement of educational institutions. Every student in London who can pass the prescribed examinations can at present obtain a degree. No change in existing arrangements need be made unless it can be shown by some other method students could be attracted in greater numbers, or could be turned out at the end of their university careers with a greater mastery of the branches of knowledge which they have studied. These ends will not be attained by giving to the existing colleges the right to agree among themselves as to the conditions on which degrees are to be bestowed, and leaving the existing university as a rival whom they will immediately be tempted to undersell. If public money were bestowed on such a university it would merely be scrambled for by the constituent colleges, and would be spent in a rivalry in which the minimum advantage to learning would be produced by the maximum waste of funds.

If London is to have a University worthy of the name, if Parliament, the City Companies, and the London County Council are to provide it with the means absolutely necessary for its proper equipment, the University must be endowed with powers which will enable it to fashion the Colleges to meet the needs of London. It must be freed from, not fettered and hampered by, the necessity of maintaining in precisely their present form arrangements which are themselves in large measure the result of the religious animosities of fifty years ago.

But while this fundamental fact must in every way be insisted on, it would, of course, be absurd to attempt to compel the governing bodies of existing institutions to surrender all their rights off hand, or to treat as hostile men who have been doing their best for the public good amid great difficulties and with too little public sympathy. We cannot, therefore, but hope that the Commission may recommend, and the Colleges accept, some such plan as that recently proposed by the Professorial Association.

In this scheme a praiseworthy attempt has been made to combine a rigid insistance on the conditions necessary for the future success of the University, with a due regard for the susceptibilities of the Colleges out of which it will in part be constituted. It is proposed that the Governing Body shall consist of the Chancellor and the Vice-Chancellor, and twenty-five Professors (each of whom shall be elected annually by the Professors of a definite group of cognate subjects), together with fourteen members nominated by the Crown, four members nominated by its Corporation and the London County Council, three representatives of Convocation, and four members, not being teachers in the University, nominated by the Governing Body itself.

The last provision would enable the Court—as the Governing Body is called—to give temporary or permanent representation to public or semi-public bodies which it might be desirable to attach to the University. It is also proposed that the arrangements between the University and the existing colleges shall be negociated by a Statutory Commission with very wide powers, subject always to the condition that every Professor of the University, wherever he may teach, shall be appointed and paid by the University. To this Commission is entrusted the task of selecting in the first instance the fourteen members of the Court, whose successors will be nominated by the Crown. The choice is to be made "from among the existing members of the Senate of the University of London, and from members of the governing bodies of those colleges which may be incorporated, in such proportion as may seem advisable to the Commission, having regard to the importance of the vested interests involved, and to the magnitude of the educational resources which may be placed by each at the disposal of the new University. These initial appointments are to last for ten years, and at the end of ten years, or in the event of vacancy through death or resignation, the appointments are to be made by the Crown." Subject to the general control of the Court the Professors of the University are to have charge of all purely educational matters.

The colleges named as those which it is desirable to bring into connection with the University are (in alphabetical order) Bedford College, the Central Institution of the City and Guilds Institute, Gresham College, King's College, the Medical Schools, the Royal College of Science, and University College, while there are other institutions, especially those giving instruction in Fine Arts and in Law, with which it may be possible for the University to establish relations. It is also proposed that the University should have the power to appoint or to recognise teachers giving instruction of a more or less academic character at institutions or colleges, the objects

or the standing of which render complete incorporation with the University undesirable, and to institute "University Extension" lectures, always, however, subject to the condition that the teaching functions of the University are to be confined to the metropolitan area. The examinations of the existing University of London would of course be carried on, so that in this part of its work the University would maintain its connection with all parts of the kingdom, and indeed of the empire.

In all these points the suggestions of the Association appear to us to be eminently practical. It is hopeless to expect a solution of the problem to which every one will agree. The first desideratum is to secure the establishment of a new non-federal teaching University, and then to give a statutory commission the power to make bargains with the existing colleges, which must either assent to reasonable terms or be left outside the University altogether. If any Governing Body consents to a close incorporation with the University it will secure representation on the Court both from among its lay members and its Professors. When the University is fairly started the Crown will select persons who are or are not connected with the Colleges as may seem desirable. The Medical Schools will be free to make terms with the Statutory Commission or to remain independent as they please. Of course the Commission ought to be as strong as possible, and much will depend on it, but with the suggested constitution it would be impossible to make the University a federation. It would be independent of and superior to the Colleges. It would be powerful and important enough to bulk large even in London, and to attract help both from the State and the Municipality.

COMPARATIVE GEOLOGY.

Text Book of Comparative Geology. By E. Kayser, Ph.D., Professor of Geology in the University of Marburg. Translated and edited by Philip Lake, M.A., F.G.S., late Harkness Scholar in the University of Cambridge. With 596 Illustrations (73 plates and 70 figures in the text). (London: Swan Sonnenschein. New York: Macmillan and Co., 1893.)

AMONG works dealing with stratigraphical or historical geology, Dr. E. Kayser's "Lehrbuch der geologischen Formationskunde" holds a deservedly high place. The account given in this work of the several geological systems, as displayed in Germany, is very full and complete; and the comparisons of the German strata with their equivalents in other parts of Europe are for the most part judicious and accurate. A very striking and admirable feature of the book is its wealth of illustration; carefully selected specimens of the characteristic fossils of the several formations, are figured in such a way as to be clearly recognisable, and there is probably no text-book of the kind in which the number of forms thus represented is anything like so great.

We cannot but think that Mr. Lake has rendered a great service to geological students in this country by translating Dr. Kayser's admirable text-book; and for the general manner in which he has performed his task we have nothing but praise. When a detailed examination of the book is made, however, it is impossible not to be struck with a certain inequality of treatment on the part of the editor: and as we sincerely hope this excellent book may reach a second edition, it may be well to call attention to points in which it is certainly susceptible of improvement.

There are two ways in which a teacher of geology in any particular country may advantageously introduce his students to the comparative study of the several formations. He may, in the first instance, describe the formation as displayed in an area where his students can make direct acquaintance with it, and then proceed to point out the resemblances and differences presented by the various foreign equivalents of the formation; and there is certainly much to be said in favour of thus making geology "begin at home." But, inasmuch as the several systems of strata are very unequally developed in different areas, there is often a very obvious advantage in following a different plan. If the district in which the most perfect exhibition of a system of strata can be studied be selected as the *type*, and all other areas be directly compared with this typical representation of the system, it is evident that a more satisfactory account of a formation can thus be given in a limited space than is possible by the other method.

Now as regards the Palæozoic formations, we think that Mr. Lake has been very happy in the methods he has adopted. In the case of the Cambrian, Ordovician, Silurian, and Carboniferous systems, he has commenced with an account of their development in the British Islands. The Devonian and Permian are, however, differently dealt with, the type of the first being sought in the Eifel and of the second in Central Germany. Nothing could be better for the purpose aimed at than this blending of the two different methods of treatment to which we have referred.

In his preface the author acknowledges the assistance received from Mr. Marr and Prof. Lebour in preparing the account of the Palæozoic rocks; and every one must be satisfied with the general accuracy and fulness of treatment of the British strata and their equivalents, so far as the great Palæozoic systems are concerned.

The most serious criticism which we have to offer with respect to this earlier portion of the work is as regards the limits adopted for the Cambrian. Mr. Lake divides this system into three portions, characterised by the *Olenellus*, the *Paradoxides*, and the *Olenus* fauna respectively; he nevertheless takes away from the Cambrian the Tremadoc beds, in which *Olenus* is so abundant, and makes them the base of the Ordovician. We think that, in a work intended for English students, it would have been better to have followed the practice which has hitherto prevailed in this country, and to have included the Tremadoc in the Cambrian, giving a reference to Dr. Kayser's views in a footnote.

We also find in the preface an admission that "additions are most numerous in the first half of the work, while in the latter half the greatness of the subject and the limits of space have made themselves more severely felt." In the account of the Jurassic and Cretaceous strata there are not a few important facts with respect to the British representatives of those systems that are altogether omitted; while there is, we think, a dispropor-

tionate amount of space given to some foreign equivalents. It is when we come to the Tertiary strata, however, that we are most painfully impressed by the inadequacy of the treatment of some very essential matters. The British Eocenes have about half a page devoted to them; there is no mention of the Hampshire Basin as distinct from that of London; and the table of strata given is neither that of one basin nor the other, but an awkward combination of beds from both. The English Oligocene is dismissed in about a dozen lines, and no mention is made of the rich and varied marine fauna of the New Forest. About the same amount of space is devoted to the Pliocene of East Anglia (that of the South Downs and Cornwall not being even mentioned), while the highly-developed Pliocene of Belgium has assigned to it only a single line.

We make these remarks, not with any desire to find fault, but in order to call the author's attention to the fact that, in its present state, the work would be almost useless to an English student, unless he used it in conjunction with another geological text-book, in which the British formations had received more adequate treatment. If the more vigorous editing, which has made the first part of this book so excellent, were applied to the latter half of the volume, we should then have an almost perfect work, and one which would find a place in every scientific library.

With all its faults, however, we have a text-book of stratigraphical geology which is superior to all its predecessors in respect to its illustrations, and its thoroughness. The copious index is of the greatest value, though the work would be improved by some additions to the references and the substitution in all cases of citations of original memoirs in the place of works giving information at second hand.

The plan of treatment of the several geological systems is excellent. The historical account of the establishment of the particular division and grouping of the strata is followed by sketches of the development of the system in the chief European areas, concluding in certain cases with shorter notices of some of the extra-European equivalents. This account of the stratigraphy of the system is followed by an admirable sketch of its palæontology.

There are two portions of the book which, to make the work suitable as a manual for English students, require to be greatly modified, if not altogether rewritten. These are the chapters relating to the Archæan and the "Diluvium" respectively. We can readily understand that the editor would shrink from so drastic a remedy as we suggest, and yet the views expressed in the book before us, upon the oldest and youngest of the formations respectively, are so entirely at variance with those which the beginner is likely to hear from any recognised teacher of geology in this country, that it is scarcely fair to students to allow them to stand in their present form. In the same way the uncompromising statements concerning the difference between the eruptive rocks associated with the tertiary and those of older geological epochs require serious qualification. If the editor felt that he could not, in fairness to the original author, make the necessary omissions or alterations in the text, he might have appended notes in which the attention of the student is called to statements that are at variance with the instruction he would ordinarily receive in this country.

Although we have felt it to be our duty to call attention to certain imperfections and blemishes in this book, we must repeat our verdict concerning its general excellence, and the hope that an opportunity will soon be afforded to its editor of preparing a second edition, in which these imperfections and blemishes may be removed.

THE BALTIC SHIP-CANAL.

Der Nord-Ostsee-Kanal. Von C. Beseke. (Kiel and Leipsic: Lipsius and Tischer, 1893.)

FOREMOST among the engineering works of the latter part of the nineteenth century must assuredly be placed the magnificent maritime canals, which afford such conspicuous evidence of industrial skill and enterprise; and of these great works few will yield in point of size and importance to the new sea-way between the North Sea and the Baltic, the history and progress of which is so ably described by Herr Beseke in the present volume.

The idea of such a canal has been under consideration for five centuries, and one of the most interesting chapters in the book is that which enumerates no less than sixteen schemes which have from time to time been propounded for the accomplishment of this difficult problem. These different projects are rendered all the more intelligible by means of a sketch-map, indicating the various lines proposed, the majority of which, having their origin in the estuary of the Elbe, passed transversely across the Schleswig-Holstein peninsula to points in the vicinity of Kiel or Lübeck.

The inception of the present undertaking dates from October 19, 1883, when the Chancellor of State was directed by Imperial rescript to report upon the execution of a canal from Kiel to the mouth of the Elbe. The plans, prepared in conformity with this decree, were adopted, with trifling modifications, on March 16, 1886, the execution of the works being entrusted to a State Commission in July of the same year, and the first stone was laid by the Emperor William I. with an imposing ceremony on June 3, 1887.

The total length of the projected canal is about 61 English miles, the width at the water-line is 197 feet, and at the bottom, at the toe of the slopes, 72 feet; the total depth is nearly 28 feet. It is shown by means of a diagram that not only will two of the largest Baltic merchant vessels pass one another without difficulty, but also that there is room for a vessel of this type to give way to one of the finest ironclads of the German navy, such as the *König Wilhelm*, with a displacement of 9757 tons. Special passing stations have, however, also been arranged at intervals, similar to those on the Suez Canal.

The cost of the works was originally estimated at £7,800,000, which provides for 77,400,000 cubic metres of excavation, and all requisite contractors' plant and materials, entrance locks, bridges, and harbour works, as also for the forts needed to protect the western approach to the canal.

A most curious chapter is that which deals with the provision made for the conduct of the enterprise, and for the housing and accommodation of the large staff of workpeople engaged therein. The sub-contractors for

the various sections into which the works were divided—15 in number—had, under conditions carefully specified, to construct barracks for the staff of workers. The canteen arrangements were all carefully thought out, and the prices of food were regulated by fixed tariffs. The sizes of dormitories were prescribed; hospitals and laundries have to be provided, and all the sanitary arrangements appear to be most complete.

It was a condition of their engagement that the workpeople should be at least seventeen years of age, no Socialists or Anarchists might be employed, and all drunken and dissolute persons were liable to instant dismissal. Some of the regulations appear slightly autocratic, but doubtless with a population of from 6000 to 8000 persons brought together from all parts of Germany, such as was to be found on certain of the sections, it was necessary to insist upon a very severe discipline. We are assured by the author that hitherto these rules have worked satisfactorily. A detailed account is given of the four bridges required for the railway crossings, also of the numerous ferries and of the massive constructions needed to form the entrance-locks of the canal at either end. The water-level of the canal is almost coincident with that of the Baltic. So that on 340 days in the year the sluices can remain open, and the lock-gates into the Elbe can be opened daily at certain states of the tide; the water in the canal is to be at one uniform level throughout.

In consequence of the advanced state of the works it seems probable that the undertaking may be formally opened for traffic at the period originally contemplated, in the summer of 1895. Steamers will be permitted to propel themselves at a mean speed of about six miles an hour, and sailing vessels and barges will be towed in train through the canal by steam-tugs provided for this purpose.

Herr Beseke presents us with most exhaustive statistics showing the saving in time caused by the use of the canal as contrasted with the dangerous passage round the coast of Denmark, and a wreck chart of the entrance of the Baltic serves as an effective object-lesson of the value to navigation of this new sea-way.

In the concluding chapters we find most ample details of the volume of Baltic commerce and of the tonnage engaged therein, both in the form of steamers and sailing vessels, and excellent diagrams and charts have been specially prepared by the author to render these facts readily intelligible to the public. Nor does Herr Beseke omit to treat of the industrial value of these works and of their importance to the Fatherland, both from the military and naval aspects; in fact their political significance is shown to be enormous.

The volume contains a mass of well-digested information upon an undertaking concerning which but little has hitherto been heard in this country, but which is destined to exert a powerful influence upon the commerce of the states bordering upon the Baltic.

OUR BOOK SHELF.

Laws and Properties of Matter. By R. T. Glazebrook, M.A., F.R.S. (London: Kegan Paul, Trench, Trübner and Co., 1893.)

THIS is the latest addition to the manuals on "Modern Science" which are appearing under the direction of Sir John Lubbock. It is concerned with the meaning of the terms applied to matter, and with the principal properties which matter possesses, and contains chapters upon units of measurement, force and motion, work and energy, the forms of matter and of energy, and upon the properties of solids, liquids, and gases.

The book is an excellent introduction to the study of the physical properties of substances, and meets the main difficulty of the beginner by supplying him with sound ideas on the ground-work of his subject. It is indeed a matter for regret that there are so few similar books on other branches of science.

Although the properties discussed are almost entirely mechanical or physical, the author occasionally touches upon the subject matter of chemistry, and here the chemical reader may perhaps be puzzled to find the term "molecule" applied in cases where he has been taught to use the term "atom." The molecular weights given on p. 184, for example, are the ordinary atomic weights of the chemist. It is impossible, however, to correctly discuss even such chemical phenomena as are given in the book, without employing the conception of atom as well as that of molecule. Thus on p. 183 it is stated that "by adding to each molecule of carbonic oxide a second molecule of oxygen we get carbonic acid." This conclusion is not in harmony with Avogadro's hypothesis, for carbonic oxide unites with half its volume of oxygen to form carbonic acid.

The value 411° is much higher than those recently obtained for the critical temperature of water. On p. 19 "dynes in a given mass" should be "dynes in a given weight." The formulæ on pp. 164 and 180 are not correctly printed. J. W. R.

The Partition of Africa. By J. Scott Keltie. (London: Edward Stanford, 1893.)

THE author of this book does not wish it to be regarded as a contribution either to the geography of Africa or to the history of African exploration. His object has been to present "a brief connected narrative of the remarkable events which, during the last eight years, have led to the partition of the bulk of Africa among certain of the powers of Europe." In carrying out this purpose, Mr. Keltie displays wide knowledge, sound judgment, and an admirable power of lucid and effective exposition. The details of his narrative do not come within the scope of NATURE, but we may note that in his occasional references to the scientific aspects of the subject he invariably gives evidence of a thorough grasp of the principles which can alone be of vital service in the study of geography. This is especially true of a luminous and interesting chapter on "the economic value of Africa." The importance of the work is greatly increased by a large number of carefully-selected and well-executed maps.

Forest Tithes, and other Studies from Nature. By a Son of the Marshes. Edited by J. A. Owen. (London: Smith, Elder, and Co., 1893.)

BY "forest tithes" are meant the quantities of food secured at the expense of rural folk by wild creatures of the moorlands. The subject is an attractive one, and in dealing with it the author of this little volume presents many bright and lively sketches of animal life. The essays on other subjects are in their own way not less pleasant. They all display an ardent love of nature and a remarkable power of minute and accurate observation—qualities which have won for "a Son of the Marshes" a place of his own among the popular writers of the day. Some of the articles have already appeared in various publications; others are now printed for the first time.

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.*]

Locusts at Great Elevations.

THE following account of the occurrence of swarms of locusts at great elevations in the Himalaya, and these stripping birch trees, is from a privately printed record of an expedition to the north-east of Kinchinjunga, in 1891, by Mr. White, the British resident in Sikkim. That flights of locusts are carried from the plains of India up to great heights in the Himalaya is a well-known fact; but not, I think, in the numbers nor with the results to birch or other forest trees here recorded.

The Camp, April. J. D. HOOKER.

"On July 19, 1891, I crossed the Lunglala Pass, 17,400 feet . . . . On the Pass I saw the locusts that had infested Darjeeling, for the first time, though subsequently I saw them as high as 18,000 feet, where they were dying in the snow. It will be remembered that this was the year of the great plague of locusts in Malie. I heard that they had penetrated even into Tibet. On the 21st I came down as far as Tangu, 12,750 feet, where the locusts were in swarms and dying in thousands. The only plants they seemed to care about were the birches, and these they stripped bare."

The Sandgate Landslip.

As I have just returned from Folkestone, and have had opportunities for observing the recent "landslip" at Sandgate, perhaps a note on it may be of some interest to readers of NATURE, as I do not think the explanation suggested by Mr. Blake in NATURE (vol. xlvii. p. 467) is altogether applicable to the present instance.

So far as I could see from a careful examination of the exposures, there is no trace of any movement of the solid rocks of the cliff, as these are nowhere exposed in the fissures that have been formed by the earth-movements; and my impression from all that I saw is that the "slip" has been entirely confined to the débris which has accumulated in past ages against the flank of the escarpment. On referring to the four types of Bergstürze or landslips described by Prof. A. Heim, of Zürich, some years ago in a monograph, which was summarised (with additions) by myself in the *Geological Magazine* (Decade II., vol. x. p. 160 *et seq.*), it is not difficult to identify the Sandgate incident with the first class of such phenomena, to which Prof. Heim gives the name "Schuttrutschung"; that is to say, a *slide* or *push* of an accumulation of débris (Schutt). Such accumulations often in mountain regions occur as lateral moraines or as talus; and in my paper on the origin of valley lakes (*Quar. Jour. Geol. Soc.*, vol. xxxix., February, 1883) I have attempted to show how such masses play an important part in the formation of some lakes. The Sandgate phenomenon I take to be no more than a magnified instance of what occurs in many a clayey railway-cutting, as railway-engineers know too well. There seems to be no occasion for importing the notion of "faulting" of the rocks themselves into the question. Still less rational is the notion that vibrations due to the blowing-up of one or two ships lately had anything to do with the catastrophe. The most elementary principles of mechanics explain it completely.

A mass of rock-fragments and clayey material, such as may constitute a "scree," acquires in time a certain amount of coherency from the oxidation of the irony constituents, or from the solution and redeposition of carbonate of lime (where the materials are calcareous) by carbonated atmospheric waters percolating the mass, or from both of these causes. If the mass is fairly drained internally it may retain its stable condition for any length of time, and be mistaken for a part of the solid geotectony of the district, though in cases where the materials are largely composed of decomposable silicates, it is evident that there is a tendency for the proportion of the fine slippery clay-material in the mass to increase. The consequence may be (and often is) that there is a tendency in the whole mass to settle down under the force of gravitation, and so a slow preliminary differential movement often goes on for years, before some new factor is introduced to precipitate the disaster. There can scarcely be any doubt that the new factor in this case was the excessive rainfall of last February, and the want of sufficient under-draining to carry away the water, which entered the mass of partly-compacted débris from above. A small lateral valley parallel with the general line of the escarpment had no doubt served as a catchment agent for much of this water. This supposition is borne out by the facts (1) that further to the east, where a land-drain was laid some years ago, the mass below it remained stable; (2) that above the western end of the "slip" the military hospital suffered no damage, the stability of its base being doubtless due to the complete under-draining of the site, which, as my kind friend and host Colonel Cranmer Byng informed me, was carried out before the hospital was built. It is probable, however, that at the point of maximum movement the springs from the beds which form the plateau above had much to do with the water-logging and consequent diminution of the internal friction of the débris which moved, and that the action of those springs was exceptional or excessive in the early part of this year, owing to the rise of the water-line in the ground at the back of the escarpment.

I have talked the matter over with Mr. Topley, who is an expert on all matters of Wealden stratigraphy, and he agrees generally with me as to the real nature of the phenomenon. There is one obvious and only preventive against its recurrence.

Wellington College, Berks, April 15. A. IRVING.

"Roche's Limit."

I MUST thank your correspondent G. R. for correcting my carelessness in giving Roche's limit round the sun as about a tenth of the earth's distance, instead of about a ninetieth as it really is.

If R is the radius and D the density of a spherical planet, and d the density of the tidally disturbed and infinitesimal satellite, moving in a circular orbit so as always to present the same face to the planet, then the distance at which the satellite is on the point of being broken up by the tidal forces is $2{\cdot}44\,R \times (D/d)^{\frac{1}{3}}$.[1] This is Roche's limit, and the formula is correctly stated by G. R.

The mean density of Jupiter is about one third greater than that of water, and it does not seem unreasonable to suppose that the density of the fifth satellite may be as low as 2. This would bring the limit to 2·13 R.

Any plausible hypothesis as to the density of the stones forming Saturn's rings will no doubt bring the limit somewhat inside the outer edge of the rings.

I must plead guilty to not having made these numerical estimates whilst writing my review of Mr. See's paper. However, it still seems to me that the coincidences which I there noted are very remarkable.

The simple illustration by which G. R. obtains a fair approximation to Roche's limit is very interesting.

The satellite is replaced by two small spheres of density d and radius r, touching one another, in line with the large sphere of density D and radius R. Suppose that when the point of contact is distant c from the centre of the large sphere, the small spheres are on the point of being pulled apart; then c is the approximation to Roche's limit. G. R.'s condition is that the excess of the attraction of the large sphere on the nearer small one above the attraction on the further one is equal to the attraction between the small ones. In algebraical language this becomes

$$\tfrac{4}{3}\pi DR^3 . \tfrac{4}{3}\pi dr^3 \left\{ \frac{1}{(c-r)^2} - \frac{1}{(c+r)^2} \right\} = (\tfrac{4}{3}\pi dr^3)^2 . \frac{1}{4r^2}.$$

Whence

$$\frac{(c^2-r^2)^2}{c} = 16R^3 . \frac{D}{d}$$

Treating r as very small we have $c = 2{\cdot}52\,R \times (D/d)^{\frac{1}{3}}$.

If the spheres r are not very small, if $D = d$, and if R be taken as unit of length, the equation for c becomes

$$c^4 - 2c^2r^2 - 16c + r^4 = 0.$$

This quartic determines the approximate limit when the satellite is not infinitely small.

I shall now use this equation to find what size we must attri-

[1] "La figure d'une masse fluide soumise à l'attraction d'un point éloigné." E. Roche. *Acad. des Sci. de Montpelier*, vol. i. (1847-50), p. 243.

bute to the small spheres, so that all three spheres may touch one another. They touch when $c = 1 + 2r$; whence we get

$$9r^4 + 24r^3 + 22r^2 - 24r - 15 = 0,$$

the solution of which is ·85078.

Hence if the smaller spheres have their radii ·85078 of the large one, they are all three in contact, and there is no pressure between the small ones, when they revolve with proper orbital angular velocity. Now the analogue of this solution in Roche's problem is very interesting. The problem is to find the relative sizes of planet and satellite, so that where the satellite is in limiting equilibrium the two bodies shall just touch. The solution will give a fair approximation to that hour-glass figure of equilibrium of rotating fluid, which I have treated otherwise in a paper in the Philosophical Transactions (vol. clxxviii. A., p. 379). The solution would be improved, although complicated, by allowing the larger body to be also deformed.

Unfortunately the solution requires the tabulation of several functions depending on elliptic integrals. Roche made, but did not publish, tables of certain integrals, which he used for obtaining his results. It appears that the problem to which I refer did not occur to him.

Some years ago I began the computations necessary for this solution, but as it appeared to be a much more laborious task than I had anticipated, I have put the work aside until I should find leisure to attack the problem again. G. H. DARWIN.

April 10.

The Afterglows and Bishop's Ring.

I AGREE with your correspondents (pp. 101 and 127) that there has been a marked increase in the amount of dust in the upper regions of the atmosphere within the last few months, as evidenced by sky phenomena.

I did not notice the sunset of November 27, and it was not till the next morning I observed any increase in the dust phenomena here. About sunrise on the 28th "Bishop's Ring" was very conspicuous for the first time for a considerable period, as also were the whitish wisps in and near it, very similar to those forming such a noticeable feature of the Krakatão sunsets; but I have never again seen them so small and definite as when those sunsets first took place. The sunset of that day (November 28) was a magnificent and striking one, with a very deep pink glow. On the 30th there was a somewhat definite bright segment below the rosy glow, at first a dull buff, and then orange. This segment was a very striking feature of the earlier Krakatão sunsets, but I have rarely seen it since till that day. I noticed it again on December 4. The wisps continued to be very conspicuous up to December 13, after which date they gradually grew less so, and have now disappeared altogether.

After the middle of December I was travelling in Portugal, the Canaries, and Spain. The segment was invisible—or at any rate not a noticeable feature—after December 19 to January 30; but most of the time I was not favourably situated for seeing it on account of hills. From the last-mentioned date to February 11 (during which time I was in the neighbourhood of the Straits of Gibraltar) the sunsets—generally on a cloudless sky—were very striking, and almost nightly the orange segment was very bright and definite, though I think not quite so definite in outline as in the Krakatão sunsets, but it reminded me much of them. As I had not been in that locality before, I do not know whether such sunsets are common there, or whether the phenomena were due entirely to a general accession of dust.

Since returning to England on February 14, the segment has sometimes been visible, though much less striking than in Spain.

"Bishop's Ring" still continues very conspicuous about sunset. I have not seen it of late years when the sun has had any considerable altitude, except on the 18th ult., from 1.30 to 3.30 p.m.; I was then in Teesdale at from 1300 to 1700 feet above sea-level; it was quite plain when the sun was behind a cloud, and visible even with the sun free from clouds. It has never ceased to be visible at about sunrise and sunset since November, 1883, although at times very faint. Has it always occurred when the sun is near the horizon, and is it only because attention was called to it by its remarkable vividness at the time of the Krakatão sunsets that one has been able to see it ever since, though never before? Unlike Mr. S. E. Bishop I always see a certain amount of red in the outer margin; though in the late accession to its conspicuousness the red has been very dull, rather to be called dull brown than red. This has also been the case at times before.

One other feature of the Krakatão sunsets has occasionally been visible of late in this country, namely, the second pink glow in the western sky. This was much more striking in Teneriffe, though still much fainter than in the Krakatão sunsets.

It would appear that if this dust is the same as that seen at Honolulu, it took six weeks to get from there to Dublin and Sunderland, while the Krakatão dust took two months in reaching the south of England from Honolulu.

Sunderland, April 10. T. W. BACKHOUSE.

Thunderstorms and Auroral Phenomena.

I AM residing in tropical Queensland, lat. 21° S., and consequently am not likely to see any auroral phenomena, particularly in the middle of our hot and rainy season; but last night between 8 and 9 P.M there occurred the following remarkable appearances, which were seen by me and several others.

There was a sharp thunderstorm with incessant lightning visible on the southern horizon, occupying a width of 10° and an altitude of from 5° to 10° above the horizon, probably from 80 to 100 miles off.

But for the distant thunderclouds the sky was clear and starlight, with a few light cirrhus clouds drifting before the north wind.

I was sitting on the lawn watching the distant flashes, when suddenly a patch or cloud of rosy light—5° to 6° in diameter—rose up from above the thunderstorm and mounted upwards, disappearing at an elevation of from 40°–45°. There were about twenty to twenty-five of these patches in the course of half an hour, sometimes three or four in quick succession; they took from one to two seconds to mount, and were not associated with any particular flash; the rosy colour contrasted strangely with the silvery light of Nubecula Major just above. There were also occasional streamers, sometimes bifurcated, of 2° in breadth, which shot up in the same way as the auroral streamers, which I have seen both in the arctic and antarctic zones.

Auroral phenomena are known to be electrical manifestations, but here were the same phenomena exhibited in connection with a thunderstorm in the tropics. Thinking this phase of electrical action worthy of note, I send you this account and enclose my card. J. EWEN DAVIDSON.

Branscombe, Mackay, Queensland,
February 5th.

P.S.—The thunderstorm, patches of light, and streamers were distinctly *connected*; it was not a case of an ordinary aurora, with a thunderstorm interposed.

Fossil Floras and Climate.

SIR WILLIAM DAWSON demonstrates that the plants of the cretaceous and tertiary series of Canada prove that the temperature of Greenland during the tertiary period was mild but not subtropical. That is sufficiently extraordinary, but geologists prefer, with strange inconsistency, the more astonishing contrast between Heer's arctic miocene palms and the glacial period. The fact is that these floras, comprising a few large-leaved evergreens and relatively tender ferns and coniferæ, are not normal in such high latitudes, but confined to localities which might have been stations on the north coast of a warm Atlantic Ocean. Therefore they perhaps require nothing more prodigious than the circulation of a gulf stream in an Atlantic isolated from the Arctic Ocean, a probable state of things at that time. At all events tertiary plants collected from near the Equator negative any generally enhanced temperature.

This applies solely to the tertiary period, when many actually living species of plants were in existence. As we recede in time species become more strange and extinct, and likely to mislead. No wise person would define, for instance, from surviving cycads the climatic conditions they may have endured when as common and widely diffused as blackberries are to-day. Even estimates based on such a group as Gleichenia may be quite inapplicable when they sustained the *rôle* now usurped by the bracken.

Sir William Dawson is aware that with even the best preserved fossil leaves, and with access to the most complete herbaria in the world, half-a-dozen different conclusions may be come to in

succession; while single and imperfect specimens are mere pitfalls. No imperfect or indistinct leaves, unless they possess exceptional characters, should be named, since however faithfully described or figured, they are simply confusing.

J. STARKIE GARDNER.

WILD SPAIN.[1]

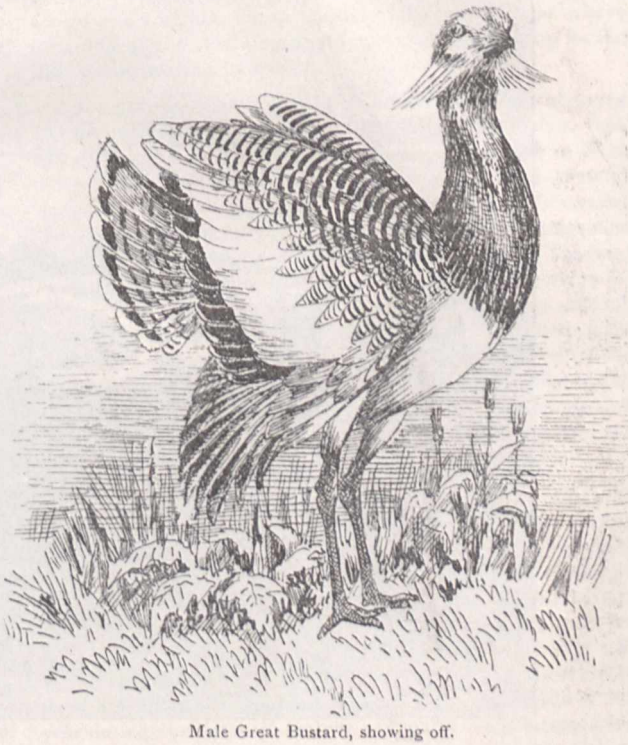
THERE seems to be no limit in these days to the demand for books on popular natural history, especially when they combine a certain amount of science with a sporting element. The present volume, in which the authors endeavour to describe Spain from "a point of view hitherto almost unoccupied, that of the sportsman-naturalist," excellently illustrated as it is, will, no doubt, attract a host of readers, for it deserves to do so. One of the joint authors, Mr. Abel Chapman is already known to us as a writer on the bird-life of the Scotch Borders, and as an ornithologist who has laboured very successfully on the birds of Spain. His coadjutor, Mr. Walter Buck, who is resident at Jerez, has long devoted himself to the exploration of the lower valley of the Guadalquivir and the bordering Sierras—the most interesting districts of the whole peninsula.

Although the larger mammals of Spain are by no means neglected, and even such extraneous subjects as corn, wine, oil, brigands and gypsies are cursorily treated of, "Wild Life in Spain" is emphatically a "bird-book." After their digressions on other points the authors return to their feathered favourites with a zest which shows that the study of the bird-life of the peninsula, combined no doubt with an ardent love of "la chasse," was the primary object of their wanderings.

In the fauna of Wild Spain the abundance of the larger birds of prey forms a very prominent feature, and several chapters are well devoted to this part of the subject. Almost all the finest and largest Raptors of the European ornis are to be met with in Spain. To the ornithologist, who in these latter days may search the greater part of "Wild Britain" without finding anything more exciting than a stray kestrel or a fugitive sparrow-hawk, this superabundance of the larger Falconidæ must prove a great attraction. Eagle-shooting, which would be a fearful crime in England, is allowable, if not praiseworthy, in the Spanish peninsula, and even an occasional vulture may be killed without much harm being done. Moreover Spain is fortunate in possessing an eagle of its own, called by modern naturalists *Aquila adalberti*, which is in fact a local form of the Imperial eagle of South-eastern Europe. But the Adalbert's eagle is remarkable as showing several successive stages of plumage which do not appear to occur in its near ally. On these we have much information in the present volume from actual experience, which seems to prove that the Spanish Imperial eagle breeds indiscriminately in its youthful and adult liveries, birds in fully adult plumage having been found paired with others in the younger forms of dress. Besides eight or nine eagles two large vultures are abundant in the south of Spain, and the celebrated Lammergeier of the Alps known to the Andalucians by the appropriate name of "*Quebranta huesos*" or "bone-snatcher" is likewise still to be met with. How the eyries of this giant bird, situated in the mountains eastward of Jerez were visited and ransacked is told to us in two attractive chapters. As the breeding-season of the Lammergeier begins in January, when the Sierras are still under snow and the weather is inclined to be severe, such an expedition is by no means free from inconveniences.

Even in wild Spain, we regret to say, the Lammergeier is yearly decreasing in numbers. "A decade ago they were fairly numerous in the vast area of rock-mountains which stretch between Granada and Jaen. To-day a week may be spent in that district without even so much as a distant view of this grand bird. The reason is unquestionably the use of poison, which is laid out broadcast by the goat-herds for the special benefit of wolves, but which is equally fatal to the Lammergeiers."

Another leading feature in the Spanish ornis is the Great Bustard, still abundant in Andalucia "on those vast stretches of silent corn-lands which form its home." "Big days with bustard," the various modes of its *chasse* and the principal features of its life are well described in "Wild Spain." It is curious that the authors do not seem to have been able to ascertain positively whether this bird is monogamous or polygamous. Even during the pairing season each band of bustards is composed of mixed sexes, the females preponderating, until the latter skulk off to perform the duties of incubation, and leave the males all together in separate packs. Bustard-shooting must indeed be glorious sport. Oh, that Salisbury



Male Great Bustard, showing off.

Plain could be restocked with this now nearly extinct (English) bird!

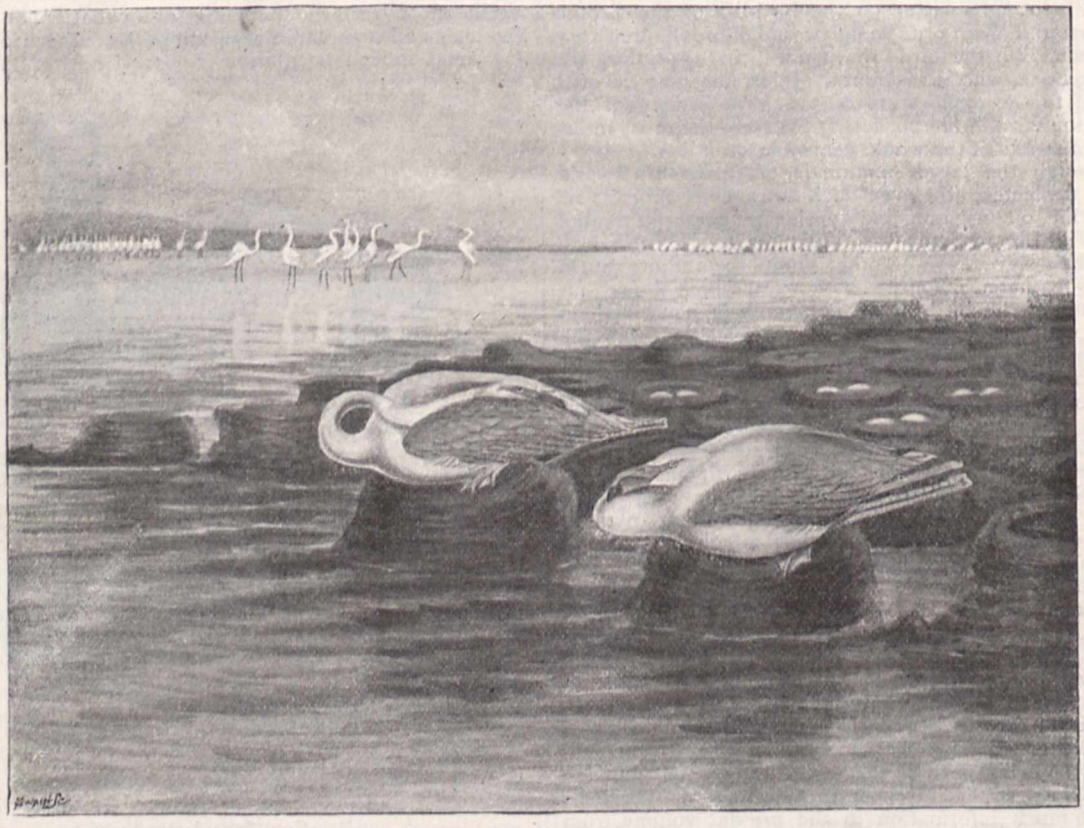
Next to the bustard the flamingo is perhaps one of the most attractive objects to the explorer of the wilds of Andalucia. In some seasons flamingoes visit the marismas in enormous flocks; in other years they are extremely scarce. In 1883 Mr. Chapman found them abundant in the month of April, and searched the country over a large area systematically, in the hope of finding their breeding-places. The exact fashion in which this bird sits upon its nest had long been a matter of controversy, and it was hoped that this interesting point might now be definitely settled. But in April all efforts were unsuccessful—it was evident the birds had not yet begun to breed—and a smart attack of ague was the only result of splashing about from day to day in the mud and water, with a fierce sun beating down upon the ornithologist's head. In May, however, during an

[1] "Wild Spain (España agreste), Records of Sport with Rifle, Rod, and Gun, Natural History and Exploration." By Abel Chapman, F.Z.S., and Walter J. Buck, C.M.Z.S., of Jerez. With 174 illustrations, mostly by the authors. (London: Gurney and Jackson, 1893.)

exploration of certain bird-islets lying off the shore of the marisma, success was at length obtained. On a low mud-island was found a "perfect mass of nests," and scattered round the main colony were numerous single nests raised above the water-level. From a distance of about seventy yards the sitting birds were observed most distinctly. "The long red legs doubled under their bodies, the knees (*scribe*, heels) projecting as far as or beyond the tail, and their graceful necks neatly curled away among their back-feathers, with the heads resting on their breasts—all these points were unmistakable." The problem was thus solved, for it had been asserted by previous authorities that the sitting flamingo, unlike other birds, straddles across its elevated nest, leaving its long legs dangling down on each side! It is only fair, however, to add that the true mode of the incubation of the flamingo has also been witnessed since, in the case of the North American species (*Phœnicopterus roseus*), by Sir Henry Blake, in the West Indian island of Abaco (see *Nineteenth Century*, December, 1887). Sir Henry has fully confirmed the accuracy of Mr. Chapman's observations.

Another curious discovery which we owe to the energy of Mr. Chapman is the existence of wild camels living and breeding in the "Bœtican Wilderness." The statement that camels were roaming about and reproducing their species in Europe at first met with much unbelief and even ridicule. There can be no doubt, however, on the subject. The camels were introduced from the Canaries in 1833, and for some years used as beasts of burden in the province of Cadiz. At the present time some stray descendants of these camels live and flourish in the marisma in a "wholly wild state," and are "practically ownerless."

Did space permit, we could well give further "elegant extracts" from this interesting volume, which is replete with information on the inhabitants of "Wild Spain," and their manners and customs. The numerous plates and smaller illustrations in the text are mostly excellent, and add greatly to the attractions of the work. We might, however, wonder that greater accuracy has not been secured as regards the spelling of some of the scientific names, especially when we are told that Mr. Howard Saunders's experienced eye has "gone through the proof-sheets. For example, *Haliäetus* is misprinted "*Haliæetus*," *Aëdon*, "*Ædon*," and *Rhopalocera*, "*Rhodopalocera*." Nor is it correct to call an Arabian camel (*Camelus dromedarius*) a "Bactrian" (*i.e. C. bactrianus*).



Flamingoes on their Nests.

It is also now well known that the ichneumon of Spain is the same as the Algerian and Egyptian species (*i.e. Herpestes ichneumon*). It should therefore be no longer called *Herpestes widdringtoni*.

NOTES.

THE conditions under which the total solar eclipse on Sunday was observed seem, on the whole, to have been favourable. According to a telegram from Ceara, the clouds at Para Cura—where the British expedition in charge of Mr. A. Taylor was stationed—were heavy before contact, but afterwards dispersed, leaving a clear space for observation during totality. The photographs were believed to be satisfactory. The eclipse was seen at Bathurst, in West Africa, "in perfectly clear

weather," and no doubt was entertained there that the British expedition under Prof. Thorpe, at Fundium, on the Salum River, had been equally fortunate. M. Bigourdan, one of the astronomers sent by the Paris Observatory to observe the eclipse in Senegal, has telegraphed to M. Tisserand, the Director: "Foggy sky; observed the four contacts; Vulcan not seen." Prof. Pickering has telegraphed to the *New York Herald* that the atmospheric conditions prevailing at Minasaris during the solar eclipse were perfect, and that the results of his observations were very satisfactory. He observed four streamers proceeding from the corona, two of which stretched over a distance of more than 435,000 miles. Several dark rifts were also visible extending directly westward from the moon's limb to the utmost limit of the corona. Several solar prominences attained great distinctness and brilliancy. During the eclipse the surface of the moon appeared almost of an inky blackness, by contrast with the dazzling brightness of the inner corona. The observations showed very conclusively that the present condition of the sun is one of great disturbance. The corona was whitish rather than red in tint. Many satisfactory photographs were taken.

THE first Royal Society soirée of the present season will be held at Burlington House on Wednesday, May 10.

THE International Sanitary Conference closed its proceedings on Friday last with the signing of a provisional convention by the representatives of Germany, Austria-Hungary, Belgium, France, Italy, Luxembourg, Montenegro, the Netherlands, Russia, and Switzerland. The delegates of the other Powers accepted the convention *ad referendum*. The ratification is to take place in Berlin within six months. According to the Berlin correspondent of the *Times*, the convention is divided into two chief sections. The first contains the international preventive measures to be taken against cholera as regards passenger and goods traffic, as well as regulations for obviating a dislocation of trade in case of an epidemic. The second section deals with the question of sanitation at the mouths of the Danube.

A COMPLIMENTARY dinner was given by the Royal Meteorological Society, at Limmer's Hotel, on Saturday evening last, to Mr. Henry Perigal, in celebration of his 92nd birthday, and of the completion of forty years' service as treasurer. A number of friends from other societies with which Mr. Perigal is connected also joined in the dinner. The President, Dr. C. Theodore Williams, in proposing the toast of the evening, gave some interesting particulars of the Perigal family, tracing their history back to some time before the Norman Conquest. The family have been remarkable for longevity. Mr. Perigal's father, who was 99¼ years of age when he died, was one of thirteen children, nine of whom attained respectively their 64th, 67th, 77th, 80th, 88th, 90th, 94th, 97th, and 100th year—the last five averaging 93 years 100 days. Their father and mother died in 1824, the former being nearly 90 and the latter upwards of 80 years of age. Mr. Henry Perigal was the eldest of six children, one of whom lived to the age of 85, and the youngest, Mr. Frederick Perigal, now in his 82nd year, was present at the dinner. Mr. Perigal briefly responded to the toast, thanking all present for their congratulations and kind wishes.

THE "Universitas Jurievensis," formerly known as Dorpat University, celebrated the centenary of the birth of the astronomer, Wilhelmus Struve, who was a professor in the University, on Saturday last, the 15th inst., by an oration delivered in the large hall of the institution.

THE Council of the Marine Biological Association has decided that in future a table in the Plymouth Laboratory may be rented for a single week, at a cost of thirty shillings. It is hoped that advantage will be taken of this arrangement in the shorter vacations. The other charges (£5 for a month, £25 for six months, £40 for a year) remain the same.

THE Council of the Durham College of Science have addressed to the governors and other friends of the institution an urgent appeal for the means of relieving the college from its financial difficulties. During the last three or four years the college income has nearly balanced the expenditure, but this has been brought about only "by the teaching staff placing the financial interests of the institution in front of their own, sometimes going the length of surrendering their fees when it has not been obvious how they were to be paid out of the funds available, and in many cases providing, at their own expense, apparatus or assistance which, under ordinary circumstances, should have been supplied by the college." This is very creditable to the teaching staff, but it is absurd that such sacrifices should have to be made by the officers of an institution established and maintained for the benefit of the people of a great and wealthy district. When the facts about the matter are generally known, the authorities of the college ought to have little difficulty in obtaining what funds may be necessary for the full development of its work.

ANOTHER terrible earthquake occurred in Zante at seven o'clock on Monday morning. It was even more violent than the earthquake by which so much damage was done in February. Other shocks were afterwards felt. The town of Zante was almost destroyed, the church of St. Dionysius, the theatre, and the prefecture being among the buildings now in ruins. According to the accounts telegraphed on Tuesday, seventeen persons were killed in the town, and many injured. The villages in the island have not generally suffered so severely, but one village, Gaetani, has been totally destroyed, and there has been some loss of life. A correspondent of the *Times*, telegraphing from Patras, says that at the time of the principal shock the sea receded several feet from the shore, and that a severe shock was felt at Patras, at Pyrgos, and on the western shore of the Peloponnesus.

DURING the past week several depressions have traversed the extreme northern parts of our islands and Scandinavia, causing unsettled weather in those parts, which on Sunday extended southwards, and on the following day disturbed weather became fairly general over the United Kingdom. The rainfall in Ireland and Scotland was somewhat heavy, but in the southern districts the fall was slight, and at several stations no rain fell. In the neighbourhood of London the drought had lasted thirty days, a period which has been unparalleled at any season of the year during the last half century. The day temperatures have varied considerably in different parts, the maxima on several days exceeding 60° and even reaching 67° in the midland and south-eastern districts, while in the north they have ranged from 40° to 50°. Sharp frosts have occurred during several nights, the readings on the 14th being from 5° to 8° below the freezing point in the shade over central England, and falling to 19° on the ground. On Monday an anticyclone lay over the North Sea, again bringing fine weather to the south-eastern portion of England, but on the following day depressions were approaching our north-west coasts, and a gale was blowing in the extreme north, while the general conditions were of a more unsettled type than for some considerable time past. During the week ended the 15th inst. there was a considerable decrease in bright sunshine, but still it exceeded the mean in nearly all districts.

THE Maryland State Weather Service publishes a monthly report in connection with the U.S. Weather Bureau. That for March contains an interesting article by Prof. W. B.

Clark, of the Johns Hopkins University, on the surface configuration of Maryland. The state is divided into three districts: the Appalachian Region, the Piedmont Plateau, and the Coastal Plain The inland border of the Coastal Plain marks the head of navigation, above which the inclinations of the valleys rise more steeply. This boundary is called the "Fall-line"; along it the larger cities of the Atlantic seaboard have grown up, and it marks out the leading highways of trade which connect the north and south. The prolongation of these three regions through other states is pointed out, and attention is directed to their importance as affecting temperature, rainfall, and the direction of the winds.

THE Berlin Academy has recently made the following grants:—£50 to Dr. Wulf, of Schwerin, for prosecution of his crystallographic researches; £30 to Prof. Taschenberg, of Halle, for publication of his *Bibliotheca zoologica*; £50 to Dr. Herz, of Vienna, for carrying further the reduction of the observations at the Kuffner Astronomical Observatory; £175 to Prof. Selenka, of Erlangen, for a journey to Borneo and Malacca to investigate the development of apes, and especially the orang; and £25 to Prof. Keibel, of Freiburg, for his researches on the development-history of the pig.

THE relations of the universities to the county councils in respect to technical education will be discussed to-day and to-morrow at a conference which will meet at Cambridge in accordance with arrangements made by the Cambridge University Extension Syndicate. The conference will be attended by representatives of county councils and universities, and by other persons interested in the subject. Cambridge has during the last year provided courses of lectures on various scientific subjects coming within the scope of the Technical Instruction Acts for eleven County Councils as well as for the technical education committees of other local authorities. A large part of the work done has consisted of simple scientific teaching in villages and small towns, and the attempt thus to bring the universities into closer relation with rural districts has naturally led to results of considerable interest and novelty. The results of such work and the most effective way of making progress in the future will be among the subjects discussed at the conference. Another item will be the scheme for systematic instruction in agricultural science at the university, devised by Prof. Liveing and others in cooperation with several of the county councils.

THE Cambridge University Extension authorities have already announced as part of the programme of their summer meeting to be held in Cambridge next autumn five courses of practical work in science in the university laboratories and museums, the subjects selected being chemistry, electricity, botany, physiology, and geology. As, however, the date of the summer meeting, July 29 to August 26, is too early for many teachers in elementary schools whose holidays fall during harvest time, arrangements have also been made for two courses in agricultural chemistry, specially adapted to meet the requirements of teachers sent with scholarships by their respective county councils. Each course will extend from August 25 to September 12 inclusive, and will thus include sixteen working days, on each of which several hours' work in the university laboratory will be provided. One course—conducted by Mr. Fenton, one of the university demonstrators—is intended for students who have done little or no laboratory work, but have acquired a knowledge of theoretical chemistry, and will be similar to the course given last year and attended by about 120 county council scholars. The other course—conducted by Mr. R. H. Adie, one of the Cambridge Extension lecturers—will be more advanced in character, and will be adapted to students who went through last year's course with credit, or have done similar work elsewhere. Accommodation for 120 students can be provided at these two courses.

LAST month a stone, which is valued at 17,000 rupees, was discovered at the Burma ruby mines. According to the *Pioneer Mail*, this is the most valuable ruby which has come to light for some considerable time past.

M. ÉDOUARD BRANLY gives a further account of his experiments on the loss of the electrical charge of bodies in diffuse light and in darkness, in this week's *Comptes Rendus*. He finds that a disc of polished aluminium, if it is experimented on a few days after being polished, behaves like most other metals; *i.e.* it slowly loses its charge, and the loss is approximately equal for the two kinds of electricity and independent of the kind of light to which it is exposed. If the disc has been freshly polished, however, even in diffuse light the loss is rapid, and is only slightly diminished by surrounding it by orange glass, thus showing the loss not to be due, to any great extent, to the rays at the more refrangible end of the spectrum.

IN the current number of the *American Journal of Science* there is a paper by Mr. I. Pupin, describing a method of obtaining alternating currents of constant and easily-determined frequency. For this purpose he uses a small transformer, whose primary circuit contains an interrupter of peculiar design. This consists of a stiff brass wire, stretched between the pole pieces of two permanent horse-shoe magnets, and carrying at its middle point a short amalgamated copper wire. At every vibration this copper wire dips into a mercury cup and closes the circuit of a battery; the repulsion between the current in the wire and the magnets serving to keep up the vibrations. The tension, which can be adjusted without stopping the vibrations, is altered until the wire is in unison with a tuning-fork of known pitch. In order to diminish the intensity of the harmonics which are present when the current is interrupted in this way, the primary of the transformer is joined in series with another coil, having a movable iron core, and in parallel with a condenser of variable capacity. The capacity and self-induction of the circuit are by these means altered till the natural period of the circuit corresponds with the fundamental of the wire. The attainment of this condition is shown by the sparking at the break being a minimum. Under these circumstances the circuit acts as a resonator, and selects from the complex E.M.F. that harmonic with which it is in resonance, and strengthens it.

FOR some considerable time continuous records have been kept at Greenwich Observatory of the earth currents along two lines approximately at right angles. However, since the South London Electric Railway has been working, the records, except during a few hours of the night when the trains do not run, have been so disturbed as to be quite valueless. These disturbances show to what an extent the current, when there is no insulated return, strays, as the railway is nowhere within four miles of the Observatory. In order to continue the earth current records and if possible trace their connection with the disturbances of the earth's magnetism, Prof. Mascart has had two earth-current lines fitted with continuous recording galvanometers, placed in the Parc Saint-Maur Observatory, and has so selected his lines that one runs exactly north and south, and the other east and west. In addition to the above a continuous record is kept of the currents passing in an aerial circuit, which is at all parts insulated from the earth.

IN the course of some investigations necessitating the elimination of small variations of atmospheric pressure, Dr. Carlo del Lungo constructed what appears to be a highly sensitive mercury barometer. As described in the *Rivista Scientifico-Industriale*, it consists of a vertical tube of 20 mm. bore and about a metre long, bent round at the bottom in the ordinary way, but having the open end closed by a steel cap screwed on to an iron collar attached to the tube. A long

capillary tube of 1 mm. bore is attached at right angles to the main tube a little above the bend, ending in an open vessel. The amount of mercury is so adjusted that there is a free meniscus about the middle of the capillary tube. Any slight increase in atmospheric pressure will then cause the main column to rise, and the necessary mercury will be withdrawn from the capillary. A fall of pressure will be indicated by a forward movement of the meniscus in the horizontal tube. Thus the rise and fall of the mercury in the main tube is exaggerated in the ratio of the sections of the tubes, in this case 400 : 1. Hence it is possible to observe a variation of $\frac{1}{400}$ mm. Should the variation of the pressure be so large as to drive the meniscus out of the tube altogether, it can be brought back by screwing the steel cylinder up or down. In spite of the errors introduced by variations of temperature and the faults due to capillary adhesion, variation of sectional area of the tube, and impurities in the mercury and the glass, the instrument appears to be well adapted to the observation of small fluctuations of pressure, such as the diurnal variation and the small and rapid oscillations peculiar to windy days. On one such occasion an amplitude of two or three centimetres was obtained in the course of two hours, during which an ordinary barometer remained perfectly steady, and a Richard barograph showed only a faintly waved line.

IF we may accept literally Sir Edward Braddon's glowing descriptions of gardens in Tasmania, that island ought to be the paradise of horticulturists. Speaking the other day before the Indian section of the Society of Arts, he said of the garden he himself cultivated there for ten years: "All the year through that garden had its charms of colour and perfume to lavish upon me; always there were life and growth in progress, and new delights unfolding themselves out of nature's bounteous lap." His monster pelargoniums, that stood from 3 to 4½ feet high, and had a circumference of 9 to 27 feet, were sources of increasing pride and pleasure to him, as they were of successive glories of flower. As for his fruit trees and vegetable garden, they yielded a never-failing supply of food for the table that in England, purchased of the greengrocer, would have cost about £100 a year. "Many another garden like unto mine is there," said Sir Edward, "in Tasmania and New Zealand, gardens in which all the fruits and flowers of the temperate zone flourish abundantly, and in which it is possible for a European to work all the year round without fear of sunstroke or frostbite." These panegyrics were uttered in the course of an address in which the speaker tried to persuade Anglo-Indians that after their term of service in the East they would find it pleasanter and more profitable to settle somewhere in Australasia than to return to England. The address is an interesting one, and may be read—with the discussion to which it gave rise—in the current number of the *Journal of the Society of Arts*.

THE Hornsey Local Board, Highgate, has set a good example to other Local Boards by organising an excellent museum of modern sanitary appliances. About two years ago it occurred to the Board that it might be well to bring together some specimens of the most improved fittings for the guidance of builders and others. Accordingly a suitable room was erected, and manufacturers were invited to send examples of their manufactures. In order to ensure the permanence of the museum it was stipulated that all articles deposited should become the property of the Board; and thus an important collection—which now occupies seven rooms—has been gradually formed. It is open free to the public on week days, and a good catalogue of the contents of the museum has just been issued.

MR. ROBERT SERVICE, of Maxwelltown, writing in the new number of *The Annals of Scottish Natural History*, says it is somewhat surprising, considering the untold myriads of voles that have overrun the sheep pastures in southern Scotland for a year or two past, that so few variations in colour have been reported. He himself has not seen any noteworthy aberration among those he has observed in peregrinating through their haunts, but the shepherds have reported an occasional pied example. Mr. Service has, however, a very strong impression that the "hill voles" are decidedly of a more smoky tint than those to be found in the lower lands among the hedges and plantations. The latter seem to develop a much ruddier colour on the fur along the back, and the general tone of gray seems much brighter than that of the voles that have ravaged the upland pastures.

MR. THOMAS STEEL continues in the *Victorian Naturalist* for February his remarks on some zoological gardens he has visited. The collection at Rundwick Park, Sydney, contains some very fair specimens of various kinds, especially among the large carnivora and the monkeys; but he thinks a visitor from abroad would be disappointed in the small number of indigenous animals. Melbourne and Adelaide seem to be better off in this respect. Of the Melbourne Gardens, as compared with those he has visited elsewhere, he has a high opinion. Nowhere has he seen more attention given to the rational housing and to the comfort of the animals.

OPPONENTS of the doctrine of evolution have often tried to support their view of the subject by reference to the supposed sudden appearance of metaspermic plants in the rocks of the Cretaceous period. In the *American Naturalist* for April Mr. Conway McMillan deals with this point in an article on "the probable physiognomy of the Cretaceous plant population." He undertakes to show, first, that the appearance of Cretaceous metaspermic plants is proved, by the fossils, not to have been sudden, but gradual, and consequently, in Cretaceous time, the general preponderance of plant-population was strongly coniferous, fern and cycadean; and second, that the conditions of Cretaceous time were such that the new and scattered metaspermic plants were placed under circumstances similar to those in which to-day variation is most rapid and plasticity is greatest for each species and even for every individual.

SOME interesting notes on alligator shooting in Trinidad are contributed by Mr. S. Devenish to the February number of the *Trinidad Field Naturalist's Club Magazine*. In Trinidad it is commonly believed that if any one attempts to touch an alligator's nest, he runs great risk of being attacked by the mother alligator, who is always on the watch to defend her progeny. While surveying on the left bank of the Caroni, Mr. Devenish came once upon one of these curious constructions, and so frightened were his eight men at his going to examine and demolish it, that they all ran away to a distance of at least twenty yards, warning him of the danger of the "Maman Caiman," which was sure to attack him. However, having beside his bowie knife at his side, his cutlass in hand, he prepared for defence, and quietly demolished with perfect immunity the large nest, in which he found a number of eggs. Of these a few were blown for his collection, and the rest left to hatch near a little fountain in his garden. After a few days the hatching took place, and it was as curious as interesting, says Mr. Devenish, "to see the little alligators, still adhering to the shells by their umbilical cords, briskly showing fight when approached, dragging the shell behind them and rushing with open jaws at anything presented to them and madly biting it."

THE Royal Dublin Society has published in its Proceedings a list of some of the Rotifera of Ireland, by Miss L. S. Glascott. The list is the result of research carried on from May to October in 1891. The number of rare and new species obtained during this short period seems to indicate that the

Rotifera are well represented in Ireland, and Miss Glascott has been induced to issue her list in the hope that it may lead other observers to study the group.

DR. JOHN STRUTHERS contributes to the current number of the *Journal of Anatomy and Physiology* an important paper on the rudimentary hind-limb of a great fin-whale (*Balænoptera musculus*) in comparison with those of the humpback whale and the Greenland right-whale. His object is to determine the interpretation which should be given to the occurrence of a part apparently so rudimentary as a thigh-bone of about the size of a pigeon's egg in a great whale. He decides that the presence of the bone in fin-whales cannot be accounted for from the point of view of function, and that the bone must be regarded only as "a vestige." In the course of his inquiry Dr. Struthers has had occasion to note the need for caution in the attempt to find a functional explanation of the presence of rudimentary structures. "In endeavouring," he says, "to assign uses to rudimentary structures, we have to keep in view that such parts may in reality serve no purpose of functional utility, may be meaningless except as the products of decreasing heredity or as the incidents of variability, and that the parts attached to such structures may be but remnants, or may be adaptations acquired amid the surrounding activities."

THE purification of water more especially for drinking purposes has assumed quite a different character since the introduction and application of the bacteriological methods now in vogue. Novel processes have in consequence been devised, whilst those already in use have received an altogether new interpretation. In two recently published papers further contributions are made to both these aspects of the subject. V. and A. Babes, in "Ueber ein Verfahren keimfreies Wasser zu gewinnen" (*Centralblatt für Bakteriologie*, July 30, 1892), describe a series of experiments which they have conducted on the removal of micro-organisms in water by means of alum. Some years ago Leeds made some investigations on this subject, and showed that by the addition of one-half grain of alum to a gallon of water the number of microbes in fifteen drops was reduced from 8100 to 80. This material has, moreover, been employed for the purification of water on a large scale in America, the amount used varying according to the water, from one-half to six grains per gallon of water. In the above paper the authors record the use of very much larger quantities of alum than Leeds, and in all cases after agitating the water with this material, they obtained an absolutely sterile liquid, although the water contained originally as many as 1200 microbes in about twenty-five drops. The number of bacteria in the sediment of a water shaken up with alum was also investigated, and was found to contain but a mere fraction of the organisms originally present. In the second paper, "Reinigung des Wassers durch Sedimentirung" (*Centralblatt für Bakteriologie*, February 8, 1893), Percy Frankland details some further investigations he has recently made on the purification of water by sedimentation. This author conducted a series of experiments some years ago on the removal of micro-organisms from water by means of agitation with different solid particles, both in the laboratory and as practically carried out during the softening of water by means of lime in Clark's process. In the present investigations attention is directed to the bacterial purification which takes place during the storeage of water on the large scale in reservoirs. The following experiment may be cited, showing the nature of the results obtained:—The Thames water before flowing into the reservoirs of one of the London water companies contained 1437 microbes per c.c. (about 25 drops); on passing out of the first reservoir there were 318 present; whilst after passing through the second reservoir only 177 were present in the c.c. Both Frank and Schlatter, the former for the river Spree, and the latter for the river Limmat at Zürich, have pointed out the reduction in the number of bacteria which is exhibited in the course of a river's flow, and the above results show clearly how important a factor is sedimentation in this process of purification.

A FULL report of the second session of the International Congress of Experimental Psychology, held in London in 1892, has been published by Messrs. Williams and Norgate.

A LITTLE book which seems likely to be of good service to young students of geometry has been published by Messrs. Macmillan and Co. It is called "Exercises in Euclid, Graduated and Systematized," and is by Mr. William Weeks, lecturer on geometry, St. Luke's Training College, Exeter. The examples are grouped in sets, each set bearing upon, and serving to impress, some fundamental fact or principle which is stated in larger type at the head of it. Thus the object of the book is to build up the pupil's knowledge, and to develop in him gradually the power to grapple successfully with difficult deductions.

SOME remarkably interesting illustrations of the zoological results obtained by the naturalists on board H.M. Indian marine surveying steamer *Investigator* are being published. They consist of plates with brief explanations of the figures. We have received Part I. of "Fishes," by A. Alcock, and Part I. of "Crustaceans," by J. Wood-Mason. In the former there are seven plates; in the latter, five.

"A DAKOTA-ENGLISH DICTIONARY" has been published by the U.S. Department of the Interior. It is an enlarged and improved version of a work prepared by a missionary, the Rev. S. R. Riggs, and published by the Smithsonian Institution in 1852. Mr. Riggs died in 1883, but had been able to get the new edition of his dictionary ready for the press. The task of editing his materials has been fulfilled by Mr. J. O. Dorsey, who has made a special study of the Siouan language, including the Dakota, since 1871.

A NEW mode of preparing hyponitrous acid, $H_2N_2O_2$, eminently suitable for demonstrating the existence of this interesting lowest acid of nitrogen in the lecture room, is described by Dr. Wilhelm Wislicenus in the current number of the *Berichte*. It will doubtless be remembered that hyponitrous acid was first prepared in the year 1871 by Divers, by reducing nitrates with sodium amalgam. Zorn subsequently showed that the molecular composition of the acid was most probably represented by the double formula $H_2N_2O_2$. He prepared the ethyl salt and found it to be a substance suitable for a determination of vapour density; the numbers obtained upon making a series of such vapour density determinations indicated that its molecular composition was $(C_2H_5)_2N_2O_2$. Several years ago Victor Meyer described an interesting reaction of hydroxylamine, NH_2OH. He showed that nitrous acid and hydroxylamine mutually decompose each other with production of water and nitrous oxide gas. $NH_2OH + HNO_2 = 2H_2O + N_2O$. It was further shown that when concentrated solutions of hydroxylamine sulphate and sodium nitrite are mixed a rise of temperature and a violent evolution of nitrous oxide occur. Dr. Wislicenus now shows that even very dilute solutions of sodium nitrite and hydroxylamine hydrochloride although cooled by ice slowly evolve nitrous oxide, eventually suffering complete mutual decomposition. The explanation of these reactions between hydroxylamine and nitrous acid has hitherto been unknown. It is now shown to be due to the fact that hyponitrous acid is produced as an unstable intermediate product.

$$NH_2.OH + NO.OH = HO.N:N.OH + H_2O.$$

It is a well-known fact that hyponitrous acid readily breaks up into nitrous oxide and water, hence the explanation of Victor

Meyer's reaction is at once apparent. To prove the fact Dr. Wislicenus shows that the silver salt of hyponitrous acid may actually be obtained from the solution at a certain stage of the reaction, and the experiment forms the best method yet described of demonstrating the formation and properties of hyponitrous acid. There is always a considerable amount of hyponitrous acid present in the slowly-effervescing liquid obtained by mixing solutions of hydroxylamine sulphate and sodium nitrite at the ordinary temperature. Much more, however, is present for a few minutes when the liquid is warmed to 50–60°. At this temperature the decomposition is sufficiently rapid to cause somewhat energetic effervescence, but by the immediate addition of a solution of silver nitrate the greater portion of the hyponitrous acid can be fixed and precipitated in the form of the bright yellow stable silver salt, $Ag_2N_2O_2$. The yield of the finely divided precipitate is about ten grams for every hundred grams of hydroxylamine.

WHEN it is desired to demonstrate this mode of formation of hyponitrous acid upon the lecture table, solutions of about three grams of hydroxylamine sulphate and the equivalent quantity of sodium nitrite are previously and separately prepared. The total amount of solvent water should not exceed two hundred cubic centimetres. When the time arrives to perform the experiment the two solutions are mixed and a little of the resulting liquid immediately decanted into a test glass, silver nitrate solution added, and the fact pointed out that the resulting precipitate of nitrite and sulphate of silver is white. The vessel containing the main quantity of the liquid is then transferred to a water bath warmed to 50°, when a rapid evolution of gas at once commences. The issuing gas may rapidly be shown to answer to the properties of nitrous oxide by inserting a glowing splint, and almost immediately silver nitrate solution should be added to the liquid, when the beautiful bright yellow silver salt of hyponitrous acid is precipitated.

NOTES from the Marine Biological Laboratory, Plymouth.—Last week's captures include the Polychæta *Hyalinœcia tubicola* and *Amblyosyllis* (*Gattiola*) *spectabilis*; the Mollusca *Ovula patula* and *Loligo media* (136 mm. in length of mantle!); the Decapod Crustacea *Nika edulis*, *Ebalia Pennantii* and *Cranchii*; and the Tunicata *Clavelina lepadiformis*, *Archidistoma aggregatum* and *Perophora Listeri*. The "gelatinous alga" has now entirely replaced *Halosphæra viridis*, and both spherical and elongated forms are being taken in the townets in great profusion. A single specimen of the Cladoceran *Podon*, carrying embryos, has been taken for the first time this year. Among the many animals now breeding, the following have not previously been noticed: the Cephalopod *Loligo media*; the Leptostracan *Nebalia bipes*; the Schizopod *Macromysis flexuosa* (= *chamæleon*); the Macrura *Pandalus brevirostris* and *Hippolyte Cranchii*, and the Brachyuran *Porcellana longicornis*. The *Glaucothoë*-stage of *Pagurus* has also been taken.

THE additions to the Zoological Society's Gardens during the past week include a Black-bellied Weaver Bird (*Euplectes afer*), a Pin-tailed Whydah Bird (*Vidua principalis*), an Orange-cheeked Waxbill (*Estrelda melpoda*), two Common Waxbills (*Estrelda cinerea*) from West Africa, two Amaduvade Finches (*Estrelda amandava*), two Indian Silver-bills (*Munia malabarica*) from India, presented by Miss Herring; a Greater Sulphur-crested Cockatoo (*Cacatua galerita*) from Australia, presented by Mr. H. H. Forsayth; four Red-backed Buzzards (*Buteo erythronotus*) from the Falkland Islands, two presented by Dr. Dale, and two presented by Mr. Vere Packe; three Upland Geese (*Bernicla magellanica*) from Patagonia, presented by Sir Roger T. Goldsworthy; a Herring Gull (*Larus argentatus*) British, presented by Mr. Thomas Owen; an Alexandrine Parrakeet (*Palæornis alexandri*) from India, presented by Mr. S. Hulme; a Banded-tailed Tree Snake (*Ahætulla liocercus*), a — Snake (*Dipsas cenchoa*) from Trinidad, presented by Messrs. Mole and Urich; six Green Tree-frogs (*Hyla arborea*) European, presented by the Rev. Clifford D. Fothergill; a Moorish Toad (*Bufo mauritanica*) from Tunis, a Banded-tailed Tree Snake (*Ahætulla liocercus*) from Trinidad, deposited; two Red Oven Birds (*Furnarius rufus*), a Melancholy Tyrant (*Tyranus melancholicus*) from the Argentine Republic, a white-eyebrowed Wood Swallow (*Artamus superciliosus*) from New South Wales, six Edible Frogs (*Rana esculenta*) European, purchased; a Gayal (*Bibos frontalis*, ♂) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE PHOTOGRAPHIC CHART OF THE HEAVENS.—M. Lœwy in *Comptes Rendus* (No. 13) for March 27 adds a few more words with regard to the scheme which he has suggested for determining the coordinates of the centres of the clichés. Without such a method as his, or at any rate one that has for its object the same end (that is, of shortening the work), it seems that the work of determining the positions of the chief stars will extend over some period. With 22,054 plates covering 169 cm. and corresponding to a portion of the sky 4°·7 square, the average number of stars up to the eleventh magnitude is estimated as 250. Now it is not necessarily certain that on all of these plates there will be stars whose positions are accurately known, and further, even if accurate places had once been obtained, our knowledge of their proper motions is not considered advanced enough to apply them in such an instance as this. Only the two following ways, then, seem to be left:—(1) To observe afresh with our meridian circles as many (say six) stars as will appear on each cliché and deduce their positions (thus eliminating proper motion), or (2) to adopt a system of triangulation, assuming we know the places of some of the more important position stars. M. Lœwy's method is based on the latter, in which he groups the clichés together; for instance, the first grouping would contain as many as sixteen square degrees, but the second, third, &c., would cover just twice this number. With regard to "le problème du rattachement" he says, "Malgré tous les soins pris pour exécuter les photographies dans des conditions toujours semblables, il est impossible que les coordonnées mesurées sur deux clichés voisins soient immediatement et rigoureusement comparable. Chacun d'eux, en effet, représente la projection d'une portion de la sphère céleste sur un plan déterminé, et les plans de projection relatifs à deux plaques voisines sont inclinés l'un sur l'autre d'un certain angle. Les poses ont pu être effectuées à des époques très différentes; on ne saurait donc s'attendre à ce que la situation des plaques par rapport à l'axe de la lunette, l'orientation l'échelle des mesures soient identiques dans les deux cas. Par suite il est nécessaire de faire subir aux grandeurs mesurées certaines corrections, si l'on veut qu'elles constituent un système unique et homogène de coordonnées." In his first memoir M. Lœwy ha already given the formulæ, &c., for reduction, and in the one to which we refer below he gives us an application of his method.

In *Comptes Rendus* for April 4 (No. 14) M. Lœwy states the results that he has obtained in applying his method of determining the coordinates of the stars on the clichés for the Photographic Chart. As it would be impossible to give an idea of this computation without entering into the subject at some length, it seems best that we should leave it quite alone and refer our readers to the journal itself, from which he will get full information. Suffice it for us to say that in the different methods of "raccordement" based on twenty-six well determined positions, the probable error of the equatorial coordinates amounts nearly to ±0″·1, but "comme il faut encore admettre les erreurs réelles plus fortes qui les valeurs théoriques calculées, il devient evident que le degré d'exactitude obtenu, bien que suffisant, est loin d'être exagéré."

CATALOGUE OF SOUTHERN STAR MAGNITUDES.—In vol. xii. no. 1 of the *Memoirs of the American Academy of Arts and Sciences* will be found the results in catalogue form of Mr. Edwin Sawyer's determinations of the magnitudes of southern stars from 0° to −30° Declination to the 7th magnitude inclusive.

The general plan was to observe every star three times, and out of the total number of stars in the catalogue (3415) 289 stars were observed less than this number of times, while 1048, 491, and 194 stars were observed four, five, and six times respectively, and the rest seven times or more. The various differences of brightness were estimated by Argelander's method of step-estimations, each sequence comprising ten, five, or twenty stars according to the number of stars in the vicinity observed. Commencing in the year 1882, Mr. Sawyer says that nearly half of the whole work was done in that time, an opera glass being extensively used for fainter sequences, such as those in which the stars were of the 6th or fainter magnitude a field glass was employed. During the years 1883 and 1885 the observations, as he tells us, were wholly discontinued, "owing to the injury to the eyes from the trying nature of the work." In the method of reduction the magnitudes were deduced by plotting out the sequences, graphically using the *Uranometria Argentina* magnitudes as ordinates, and the observed differences of brightness, expressed in steps, as abscissas. The arrangement of the catalogue itself is as follows:—The columns give successively the catalogue current number of the star, U.A. catalogue number, constellation, Right Ascensions and Declinations for mean equinox 1875.0, number of observations, mean magnitude deduced, U.A. magnitude, and the three last the separate dates of the observations and magnitudes.

Comparing the average differences between the magnitudes here assigned and those given by Gould, it is found that ± 0·088m. about represents it, while the average error of a single determination, assuring equal degree of precision and including besides accidental errors, the effect of systematic difference is given as ± 0·059m.

While the work was in hand eight variables were discovered, which were as follows:—U Ophiuchi (1881), U Ceti (1885), U Aquilæ and Y Sagittarii (1886), R Canis Majoris (1887), Y Ophiuchi and W Hydræ (1888), and (?) Leporis (1891), and in addition several large discordances were noticed in many values obtained (the catalogue number of these are here given), rendering these stars worthy of special attention. The volume concludes with notes, in which several suspicious cases of variables, &c., are recorded.

A NEW TABLE OF STANDARD WAVE-LENGTHS.—Under this title Prof. H. A. Rowland contributes to *Astronomy and Astrophysics* for April (No. 114) the new measurements of several metallic lines to be used as standards. The actual measures were made by Mr. L. E. Jewell, the probable error of one setting amounting to 1 part of 5,000,000 of the wave-length, and the reductions of the reading by Prof. Rowland himself. The measurements were obtained with a new machine, supplied with a screw specially made after Prof. Rowland's process. The standard wave-length of D used was the mean of the determinations of Angström, Müller and Kempf, Kurlbaum, Pierce, and Bell, and was 5896·156, different weights being given to these separate values. This value was utilised in six different ways, and the resulting table of wave-lengths from 2100 to 7700 was obtained, the accuracy of which might, as he says, be estimated as follows:—"Distribute less than $\frac{1}{100}$ division of Angström properly throughout the table as a correction, and it will be perfect within the limits 2400 and 7000."

METEOR SHOWERS.—Among the principal meteor showers for the current year, a list of which is given in the *Companion to the Observatory*, the following two occur this week, the former of which is described by Denning as "one of the most briliant showers." The radiant points are:—

Date	Radiant		Meteors
	α	δ	
April 20 ...	270°	+ 33° ...	Swift
,, 25 ...	272°	+ 21° ...	Swift; short

WOLSINGHAM OBSERVATORY, CIRCULAR NO. 35.—A plate taken with the Compton 8-inch photo-telescope, April 11, compared with a photo by Max Wolf, 1891, shows that the two stars

Es-Birm 545 18h. 28·9m. + 36° 55′ (1900)
,, 561 18h. 39·4m. 36° 52′ ,,

are var., the photo differences being approximately 9·1, 11·4; 8·8, 10·2.

GEOGRAPHICAL NOTES.

LETTERS dated March 9 have been received from the Antarctic whaling vessels confirming and extending the brief telegraphic information already published. The ships did not proceed farther south than 67° latitude, and discovered no signs of the existence of the Greenland whale, although whales of several other species were common, and there were great numbers of grampuses. In default of whaling, the energy of the crews was devoted to sealing, and the four vessels secured between them about 16,000 skins and a full cargo of oil. The seals were of several varieties, but until the return of the ships their species cannot be determined, nor their commercial value known. The weather throughout the whole stay in Antarctic waters was severe, and the formation of ice compelled the vessels to return at an earlier date than was at first intended. Flat icebergs of enormous size were seen, one being reported as fifty miles in length. The facilities afforded for scientific work were disappointing.

THE Delcommune expedition (p. 474) has returned to Europe, and M. Delcommune was received with great enthusiasm in Brussels. The expedition, together with the others sent out by the Katanga Company, has to a large extent completed the work of Livingstone and his successors in the Congo Basin, and in the main confirms the accepted geography of the region. One point of some interest which has been established is that the Lake Lanji, marked from Arab reports at the junction of the Lukuga and the Lualaba, has no existence.

THE new number of *Petermann's Mitteilungen* contains a short paper by Prof. Krümmel on recent Russian oceanographical work in the north Pacific. This is accompanied by a map of the salinity of the surface water, which extends, and in a general way confirms, Mr. Buchanan's map founded on the *Challenger* work. The centre of maximum salinity lies between 20° and 30° N., and has its centre about 170° W. A tongue of considerably fresher water stretches nearly across the ocean, about 10° N. and sweeps round the coasts of America and Asia. The diminution of salinity northward is very interesting, the curves of equal salinity sweeping through Bering Sea without regard to the line of Aleutian Islands, thus showing that so far as regards surface water, Bering Sea is simply part of the Pacific ocean, standing in very marked contrast to the Sea of Okhotsk, a fact of some interest during the present international controversy.

MR. T. H. HATTON-RICHARDS read a paper on British New Guinea at the last meeting of the Royal Colonial Institute. While giving an account of the climate discouraging to would-be white settlers, Mr. Richards describes the native Papuans from personal experience as a fine race, possessing a keen sense of justice, and most laborious and successful as agriculturists.

RECENT INNOVATIONS IN VECTOR THEORY.[1]

OF late years there has arisen a clique of vector analysts who refuse to admit the quaternion to the glorious company of vectors. Their high priest is Prof. Willard Gibbs. His reasons for developing a vector analysis devoid of the quaternion are given with tolerable fullness in NATURE, vol. xliii. p. 511. His own vector analysis is presented in a pamphlet, "Elements of Vector Analysis, arranged for the Use of Students in Physics, not Published" (1881–84). Mr. Oliver Heaviside, in a series of papers published recently in the *Electrician* and in an elaborate memoir in the *Philosophical Transactions*, supports some of Gibbs's contentions and cannot say hard enough things about the quaternion as a quantity which no physicist wants. Prof. Macfarlane, of Texas University, has added to the literature of the subject, and without altogether agreeing with Gibbs takes umbrage at a most fundamental principle of quaternions and developes a pseudo-quaternionic system of vector algebra which is non-associative in its products!

Between the years 1846–52, just at the time when Hamilton was developing the quaternion calculus, a series of papers was published by the Rev. M. O'Brien, Professor in King's College, London. The system developed by O'Brien is essentially that

[1] Abstract of a paper by Prof. C. G. Knott, read before the Royal Society of Edinburgh, on Monday, December 19, 1892.

advocated by Gibbs and Heaviside. Two products of vectors are defined, which correspond to Hamilton's $V\alpha\beta$ and $-S\alpha\beta$; and applications are given of the linear and vector function and of the operator $\alpha\partial_1 + \beta\partial_2 + \gamma\partial_3$ which somewhat resembles the quaternion ∇.

The broad argument advanced by Gibbs in his letter to NATURE is that, in comparison with the quantities $V\alpha\beta$ and $S\gamma V\alpha\beta$, which symbolise an area and a volume which "are the very foundations of geometry," anything that can be urged in favour of the quaternion product or quotient as a "*fundamental* notion in vector analysis" is "trivial or artificial." These are brave words. Let us examine them by considering what is the purpose of a vector analysis. Clearly such a calculus is intended to show forth the properties of vectors in a form suitable for use.

Having formed the conception of a vector, we have next to find what relations exist between any two vectors. We have to compare one with another, and this we may do by taking either their difference or their ratio. The geometry of displacements and velocities suggests the well-known addition theorem—

$$\alpha + \delta = \beta$$

in which by adding the vector δ we pass from the vector α to the vector β.

But this method is not more fundamental geometrically than the other method which gives us the quaternion. When we wish to compare two lengths a and b, we divide the one by the other. We form the quotient a/b, and this quotient is defined as the factor which changes b into a. Now a vector is a directed length. By an obvious generalisation, therefore, we compare two vectors by taking their quotient and by defining this quotient α/β as the factor which changes the vector β into the vector α. This is the germ out of which the whole of vector analysis naturally grows. A more fundamental conception it is hardly possible to make. Yet Gibbs calls it trivial and artificial! Far more fundamental, we are told, are the conceptions of a vector bounded area and a vector bounded volume, whose bounding vectors may have an infinity of values. Or take the more general case of a body strained homogeneously. The relative vector of any two of its points passes into its new position by a process which is a combination of stretching and turning. A simpler and more complete description cannot be imagined. It is perfectly symbolised by the quaternion with its tensor and versor factors. And *this* is trivial and artificial—as trivial, say, as the versor operation which every one performs when estimating the time that must be allowed to catch a train. . . .

Another argument advanced by Willard Gibbs is in the paragraph beginning: "How much more deeply rooted in the nature of things are the functions $S\alpha\beta$ and $V\alpha\beta$ than any which depend on the definition of a quaternion, will appear in a strong light if we try to extend our formulæ to space of four or more dimensions." To elucidate the "nature of things" by an appeal to the fourth dimension—to solve the Irish question by a discussion of social life in Mars—it is a grand conception, worthy of the scorner of the trivial and artificial quaternion of three dimensions. Further on we are told that there "must be vectors in such a space"; that is, space of four or more dimensions. True, and if there be vectors, must there not be operations for changing one vector into another? . . . .

"Vectors must be treated vectorially" is a high-sounding phrase uttered by Prof. Henrici and Mr. Heaviside. What does it mean? On the same sapient principle, I suppose, scalars must be treated scalarially, rotors rotorially, algebra algebraically, geometry geometrically. That is to say the remark is a very loose statement of a truism, or it is profound nonsense. Strictly speaking, to treat vectorially is to treat after the manner of vectors, or to treat *as vectors do*.

Now what does a vector do? Prof. Gibbs, the prince of vector purists, says on page 6 of his pamphlet that "the effect of the skew [or vector] multiplication by α [any unit vector] upon vectors in a plane perpendicular to α is simply to rotate them all 90° in that plane." Hence a vector *is* a versor. To which Mr. Heaviside in fierce denunciation: "In a given equation [in quaternion-vector analysis] one vector may be a vector and another a quaternion. Or the same vector in one and the same equation may be a vector in one place and a quaternion (versor or turner) in another. This amalgamation of the vectorial and quaternionic functions is very puzzling. You never know how things may turn out." Puzzling? Then must Heaviside find his own system as puzzling as any. For when he writes the vector product $ij=k$, he is simply acting on j by i or on i by j, and turning it through a right angle. It is impossible to get rid of this versorial effect of a vector. It stares you in the face from the very beginning.

A very sore grievance with Heaviside and Macfarlane—although Gibbs cautiously steers clear of the whole question—is that Hamilton puts i^2, j^2, k^2, each equal to negative unity, with the consequence that $S\alpha\beta$ is equal to $-ab\cos\theta$, where a and b are the lengths of α and β, and θ the angle between them. This putting the square of a vector equal to *minus* the square of its length vexes their souls mightily. It is so "unnatural," so troublesome.

Now Prof. Kelland, in Kelland and Tait's "Introduction to Quaternions," chap. iii., shows that if we assume, as do Heaviside and Macfarlane, the cyclic relations

$$ij=k=-ji \quad jk=i=-kj \quad ki=j=-ik,$$

and if in addition we desire an *associative* algebra, then *of necessity* we must have $i^2=j^2=k^2=-1$. If then, following these O'Brienites, we put what they consider to be so much simpler and more natural, namely, $i^2=j^2=k^2=+1$, we get a non-associative algebra of appalling complexity, which in the long run gives us no more than the associative quaternion algebra.

Heaviside apparently is unaware of the non-associative beauties of his system, which he believes "to represent what the physicist wants;" for he says, much to the credit of the *Philosophical Transactions*, that his system (which is demonstrably *not* quaternions) is "simply the elements of quaternions without the quaternions, with the notation simplified to the uttermost, and with the very inconvenient *minus* sign before scalar products done away with" (*Phil. Trans.*, vol. clxxxiii. 1892, p. 428).

We have seen how perfectly natural is the geometric conception of a quaternion as the quotient of two vectors; and the quaternion product is as simply conceived of as the operator $(\alpha\beta)$ which turns the vector β^{-1} into α. Space considerations quickly lead us to consider quaternions which rotate a given vector through a right angle. If we take two such right or quadrantal quaternions I I′ and operate severally on the vector α that is perpendicular to the axes of both, it is easy to show that

$$I\alpha + I'\alpha = (I + I')\,\alpha$$

gives a right quaternion $(I+I')$ bearing to I and I′ the same relation which would exist were I and I′ vectors. That is, right or quadrantal quaternions are added and subtracted according to the recognised rules for vector addition and subtraction, which so far, be it noted, are all we know about vectors. Hence in combinations other than addition and subtraction we may treat vectors as quadrantal quaternions, exactly as Gibbs, Heaviside, and Macfarlane do, although in a half-hearted fashion.

It remains now to consider wherein the systems advocated by these vector analysts improve upon Hamilton's. Do they give us anything of value not contained in quaternions?

Prof. Gibbs, having objected *in toto* to the quaternion product $\alpha\beta$, is for consistency's sake bound to object to Hamilton's selective principle of notation. His own notation is very similar in appearance to O'Brien's of old. He defines two products, the *direct* product $(\alpha\,.\,\beta)$ and the *skew* product $(\alpha\times\beta)$. The direct product is Grassmann's inner product or Hamilton's $-S\alpha\beta$; and the skew product is $V\alpha\beta$, so called probably because it has a value only when α and β are skew, or inclined to one another. Now there is a serious objection at the very outset to such a form as $\alpha\times\beta$ for the vector product of α and β. There corresponds to it no quotient amenable to symbolic treatment. The reason is, of course, that $\alpha\times\beta$ is not a complete product. Given the quaternion equation $\alpha\beta=\gamma$, any one quantity is uniquely determined if the other two are given. But it is impossible, in spite of the suggestiveness of the form, to throw Prof. Gibbs's $\alpha\times\beta=\gamma$ into any such shape as $\alpha=\gamma\div\beta$. The point is that Hamilton's notation does not even suggest the possibility of such a transformation. It is certainly inexpedient, to say the least, to use a notation strongly resembling that for multiplication of ordinary algebraic quantities, but having no corresponding process by which either factor can be carried over as a generalised divisor to the other side of the equation.

One peculiar perspicuity of Hamilton's notation arises from the fact that S and V are thrown out in bold relief from amongst the small Greek letters used for vectors and the small

Roman letters used for quaternions and scalars. A glance tells us what kind of quantity we have to deal with before we are called upon to inquire into its composition. There is no such eye-catching virtue in Gibbs's notation; and Heaviside largely destroys the contrast between the quantities and selective symbols by using capital letters for all. In print the vectors are made heavy and stand out prominently enough. But a vector analysis is a thing *to be used;* and with pencil or pen or chalk on a blackboard it is hopeless to prevent confusion between A and $\mathbf{A}$. In suggesting a suffix notation for manuscript, Heaviside unconsciously condemns his own system. Two conditions for a good notation are (1) an *unmistakable* difference between *easily written* symbols for scalar and vector quantities; (2) the scalar and vector parts of products and quotients thrown out in clear relief. This second is quite as important as the first condition. So far, Hamilton's notation easily holds its own.

A very important symbol of operation is the Nabla, ∇, which may be defined in the form $\alpha\partial_1+\beta\partial_2+\gamma\partial_3$ where $\partial_1\partial_2\partial_3$ are space-differentiations along the mutually rectangular directions of the unit vectors $\alpha\beta\gamma$. Since Heaviside and Macfarlane make $\alpha^2\beta^2\gamma^2$ each equal to + 1, they find that $\nabla^2 u$, where u is any scalar, is $d^2u/dx^2 + d^2u/dy^2 + d^2u/dz^2$. The real $\nabla^2 u$ is *minus* this quantity. When ∇^2 acts on a vector, Heaviside boldly defines $\nabla^2\omega$ as having the same significance; but Macfarlane, rejoicing in his non associative algebra, finds that $\nabla(\nabla\omega)$ is quite a different quantity from $(\nabla\nabla)\omega$. The net result attained by this tinkering of the signs is to get a pseudo-nabla non-associative with itself!

Gibbs moves more cannily. He defines separately the quantities ∇u, $\nabla\times\omega$, $\nabla.\omega$, and $\nabla.\nabla\omega$, which mean the same things as the quaternion quantities ∇u, $\mathrm{V}\nabla\omega$, $-\mathrm{S}\nabla\omega$, and $-\nabla^2\omega$. [In quaternions there is one definition of ∇, and everything else follows.] But even with these four definitions (all of which are properties somewhat distorted of the real Nabla) Gibbs finds his system lacking in flexibility. He has, so to speak, to lubricate its joints by pouring in the definitions of four other functions with as many new symbols. One of these is the Potential; the others are called the Newtonian, Laplacian, and Maxwellian. They are symbolised thus—Pot, New, Lap, Max. Their meanings will be evident when they are exhibited in quaternion form. Thus, as is well known,

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}\right)\mathrm{Pot}\ u = -4\pi u,$$

from which at once

$$\nabla^2\ \mathrm{Pot}\ u = +4\pi u$$

or

$$\mathrm{Pot}\ u = 4\pi\nabla^{-2}u.$$

Similarly, if ω is a vector quantity,

$$\mathrm{Pot}\ \omega = 4\pi\nabla^{-2}\omega.$$

Then we have

$$\mathrm{New}\ u = \nabla\ \mathrm{Pot}\ u = 4\pi\nabla^{-1}u$$
$$\mathrm{Lap}\ \omega = \mathrm{V}\nabla\ \mathrm{Pot}\ \omega = 4\pi\mathrm{V}\nabla^{-1}\omega$$
$$-\mathrm{Max}\ \omega = \mathrm{S}\nabla\ \mathrm{Pot}\ \omega = 4\pi\mathrm{S}\nabla^{-1}\omega.$$

Now, Prof. Gibbs gives a good many equations connecting these functions and their various derivatives, equations which in quaternions are *identities* involving the *very simplest* transformations. But there is no such simplicity and flexibility in Gibbs's analysis. For example, he takes eight distinct steps to prove two equations, which are special cases of

$$\nabla^{-2}\nabla^2 u = u\ !$$

Another of his *theorems*, namely,

$$4\pi\ \mathrm{Pot}\ \omega = \mathrm{Lap}\ \mathrm{Lap}\ \omega - \mathrm{New}\ \mathrm{Max}\ \omega$$

is simply the quaternion *identity*

$$4\pi\nabla^{-2}\omega = 4\pi\nabla^{-1}\nabla^{-1}\omega$$
$$= 4\pi\nabla^{-1}\mathrm{V}\nabla^{-1}\omega + 4\pi\nabla^{-1}\mathrm{S}\nabla^{-1}\omega.$$

Similarly the equation

$$4\pi\ \mathrm{Pot}\ u = -\mathrm{Max}\ \mathrm{New}\ u$$

is a travesty of

$$4\pi\nabla^{-2}u = 4\pi\nabla^{-1}\nabla^{-1}u!$$

These extremely simple quaternion transformations cannot be obtained with the operator used by Gibbs. Hence the necessity he is under to introduce his Pot, New, Lap, Max, which are merely inverse quaternion operators. . . .

Gibbs's system of dyadics, which Heaviside regards with such high admiration, differs from Hamilton's treatment of the linear and vector function simply by virtue of its notation. In his letter to NATURE he gives reasons why this notation is preferable to the recognised quaternion notation. As developed in the pamphlet, the theory of the dyadic goes over much the same ground as is traversed in the last chapter of Kelland and Tait's "Introduction to Quaternions." With the exception of a few of those lexicon products, for which Prof. Gibbs has such an affection,[1] there is nothing of real value added to our knowledge of the linear and vector function. As usual, the path is littered with definition after definition. Thus the *direct product*[2] of two dyads (indicated by a dot) is defined by the equation $\{\alpha\beta\}.\{\gamma\delta\} = \beta.\gamma\alpha\delta$. Quaternions gives at once

$$\phi\psi\rho = \alpha\mathrm{S}\beta(\gamma\mathrm{S}\delta\rho) + \&c. = \alpha\mathrm{S}\delta\rho\mathrm{S}\beta\gamma + \&c.$$

Then there follow the definitions of the *skew* products of ϕ and ρ, thus—

$$\phi\times\rho = \alpha\lambda\times\rho + \beta\mu\times\rho + \gamma\nu\times\rho$$
$$\rho\times\phi = \rho\times\alpha\lambda + \rho\times\beta\mu + \rho\times\gamma\nu.$$

These are not quantities but operators. To see what they mean let them operate on some vector σ. Then we find

$$\phi\times\rho\ .\ \sigma = \alpha\mathrm{S}\lambda\rho\sigma + \ldots = \phi\mathrm{V}\rho\sigma$$
$$\rho\times\phi\ .\ \sigma = \mathrm{V}\rho\alpha\mathrm{S}\lambda\sigma + \ldots = \mathrm{V}\rho\phi\sigma.$$

The first is simply $\phi\varpi$, the old thing! The second is a well-known and important quantity in the theory of the linear and vector function. It is interesting to note, as bearing upon the *intelligibility* of the notation, that Heaviside, who dotes so on the dyadic, writes $\phi\times\rho$ in the form $\mathrm{V}\phi\rho$, so that he makes

$$\phi\mathrm{V}\rho\sigma = -\mathrm{V}\sigma\phi\rho\ !\ !$$

As one example of our *gain* in following Gibbs's notation, take his dyadic identity—

$$\psi\ \ \{\rho\times\phi\} = \{\psi\times\rho\}\ \ \phi,$$

on which the comment is that "the braces cannot be omitted without ambiguity." The quaternion expression is $\psi\mathrm{V}\rho\phi\sigma$, where there is no chance of ambiguity, where everything is perfectly straightforward, and where there is much greater compactness in form. It seems to me that this last equation given by Gibbs condemns his whole principle of notation. It shows that one use of connecting symbols is to obscure the significance of a transformation. . . .

A beautiful example of virtually giving back with the left hand what he has taken away with the right is furnished on p. 42 of Gibbs's pamphlet. He writes: "On this account we may regard the dyad as the most general form of product of two vectors. We shall call it the indeterminate product." And then he shows how to obtain a vector and a scalar "from a dyadic by insertion of the sign of skew or direct multiplication."

This is exquisite. From the *operator* $\alpha\lambda+\beta\mu+\gamma\nu$, he forms—heedless of his high toned scorn for the quaternion product—the conception of the sum of three similar though more general products, but quiets his conscience by calling them *indeterminate!* This sum of products then becomes by simple insertion of dots and crosses the vector

$$\phi_\times = \alpha\times\lambda + \beta\times\mu + \gamma\times\nu,$$

and the scalar

$$\phi_. = \alpha\ .\ \lambda + \beta\ .\ \mu + \gamma\ .\ \nu.$$

Why, we naturally ask, is this *indeterminate* product welcomed where the *quaternion* product is spurned?

The truth is the quaternion, or something like it, has to come in; and in it most assuredly does come when Gibbs proceeds to treat the versor in dyadic form. The expression $\{2\beta\beta - \mathrm{I}\}\ .\ \{2\alpha\alpha - \mathrm{I}\}$ represents in Gibbs's notation the quaternion operator

$$\beta\alpha(\quad)\alpha\beta, \text{ or more simply } q(\quad)q^{-1}.$$

The I is called an *idemfactor* and is simply unity. . . .

There is something almost naïve in the way in which Heaviside introduces the dyadic as if nothing like it was to be found

[1] We are surprised that so much etymological erudition should accept such a monstrosity as parallelOpiped.

[2] Gibbs calls the quantity $\phi.\sigma$ (which is simply Hamilton's $\phi\sigma$) the direct product of the dyadic ϕ and the vector σ. The direct product of two vectors is $\alpha.\beta$, and this Heaviside calls the scalar product. Similarly translating the Gibbsian dialect, he speaks of $\phi\sigma$ as being the "scalar product of the dyadic and the vector"—and gets a scalar product equal to a vector! This "is most tolerable and not to be endured."

in either Hamilton or Tait. The truth is it is all there. Hamilton showed long ago that if

$$\phi\rho = \alpha S\lambda\rho + \beta S\mu\rho + \gamma S\nu\rho,$$

then

$$\phi^{-1}\rho = \lambda_1 S\alpha_1\rho + \mu_1 S\beta_1\rho + \nu_1 S\gamma_1\rho,$$

where

$$\alpha_1 S\alpha\beta\gamma = V\beta\gamma, \text{ \&c.}, \quad \lambda_1 S\lambda\mu\nu = V\mu\nu, \text{ \&c.}$$

Now Heaviside fusses greatly over this method of inverting ϕ, and any reader of § 172 ("Electromagnetic Theory," in the *Electrician*), would infer that the invention of the name dyadic suggestion this demonstration which Hamilton and Tait had somehow missed in their development of "the very clumsy way" of expressing $\phi^{-1}\rho$ in terms of ρ, $\phi\rho$, and $\phi^2\rho$. But the whole thing is given in Hamilton's "Elements" (p. 438, equation xxvii.), and in Tait's "Quaternions" (p. 89, second edition; p. 123, third edition). I would also refer to § 174 of Tait's third edition (§ 162 of the second), a comparison of which with Heaviside's tall talk in the *Electrician* of November 18, 1892 (§ 171), will show that, on the most lenient hypothesis available, our self-appointed critic of Tait's methods has never really read Tait's "Quaternions." . . .

All through his system Prof. Gibbs has refused to consider the complete product of two vectors. He has used the form $\alpha\beta$ to mean a "dyad" or operator of the form $\alpha S\beta$ or $\beta S\alpha$. What, then, can he mean us to understand by the equations—

$$\int\int d\sigma\omega = \int\int\int dv\nabla\omega \quad (\text{(2) of § 164}),$$

and

$$\int d\rho\omega = \int\int d\sigma \times \nabla\omega \quad (\text{(2) of § 165}).$$

In quaternion notation the last would be written

$$\int d\rho\omega = \int\int V(d\sigma\nabla)\omega.$$

Both equations are quite correct if and only if $d\sigma\omega$, $d\rho\omega$, and $\nabla\omega$ are taken in their quaternion meaning of *quantities*. But Gibbs has wilfully cut himself adrift from this interpretation. How, then, does he interpret these equations?

The chief arguments of the paper may be briefly summarised thus:—

(1) It is maintained that the quaternion is as fundamental a geometrical conception as any that Prof. Gibbs has named.

(2) In every vector analysis so far developed, the versorial character of vectors in product combinations is implied if not explicitly stated.

(3) This being so, it follows as a *natural* consequence that the square of a unit vector is equal to negative unity.

(4) The *assumption* that the square of a unit vector is positive unity leads to an algebra whose characteristic quantities are non-associative, and whose ∇ is not the real efficient *Nabla* of quaternions.

(5) The invention of new names and new notations has added practically nothing of importance to what we have already learned from quaternions.

EXPERIMENTAL MEDICINE.[1]

THIS volume is the fourth number of this remarkable publication, and will prove of surpassing interest to the bacteriologist, physiologist, and physician, chiefly on account of the first paper which it contains.[2]

In 1877 Dr. N. V. Eck invented an operation by which it was possible to alter the circulation in such a manner that the blood flowed from the portal vein into the inferior vena cava without passing through the liver. He succeeded in establishing an artificial opening between these veins in several dogs, and then tied the portal vein near the liver; unfortunately, only one dog lived for any length of time (two and a half months), and, owing to an accident, Dr. Eck was unable to control the result by post-mortem examination. The operation has now been repeated at the St. Petersburg Institute, and it has been found that in successful cases the blood passed entirely from the portal vein into the inferior vena cava.

The animals which successfully resisted this severe operation showed no alteration in the appetite, though after a period of ten days or so their temper underwent marked changes. Although perfectly docile before the operation, they now became bad-tempered, bit everything that came in their way, and showed undue excitement on trifling provocation. The animals became weak, and their gait ataxic, whilst the sensory apparatus was also greatly disturbed, as they often became blind, and appeared to lose all sensation of pain. In a further stage convulsions and coma supervened; though the animals occasionally recovered perfectly after a time, many of them died when the first attack of excitement and convulsions occurred, or succumbed to subsequent attacks, although, on the whole, the latter rarely proved fatal. The temperature showed no changes attributable to the veinous fistula, but the weight generally diminished until death supervened, although, in animals which recovered it reached, or even exceeded, the original weight. The appetite was good, though capricious; but a distinct relation was found to exist between the state of the alimentary canal and the attacks of excitement before mentioned. The animals which absolutely refused to eat meat remained free from the attacks, while the "crises" invariably occurred in the dogs that ate meat voraciously. It is a remarkable fact that many of them learnt by experience that meat was bad for them, and declined to take it.

Some dogs recovered perfectly, and at the postmortem it was found that a collateral circulation had been set up, so that the portal blood again circulated through the liver.

It would appear from further observations that these symptoms are due to the toxic action of the products of the transformation of nitrogenous food, the liver being unable to convert them into urea and uric acid. Carbamic acid was found in the urine of these animals, and carbamate of sodium or calcium, when introduced into a healthy animal's stomach, produced exactly the same symptoms as the fistula above described. On the other hand, it was found impossible to poison healthy dogs with the same salt, provided the setting free of carbamic acid was prevented by the simultaneous introduction of carbonate of soda into the stomach, while the introduction of both salts gave rise to all the symptoms of carbamic acid poisoning, when the circulation through the liver had been interrupted. The authors conclude, therefore, that the carbamates formed during digestion in passing through the liver are transformed into a harmless substance, and that this substance is most probably urea.

In some cases the experimenters removed the entire liver; but the animals never lived more than six hours, and fell at once into a comatose state, followed by convulsions, tetanus, and death through arrest of the respiration. Similar results were obtained by establishing a veinous fistula in the first place and tying the hepatic artery afterwards.

According to Messrs. Hahn and Nencki, who performed the chemical part of these observations, the reaction of the urine remained normal until one of the attacks of excitement set in, when it became alkaline. If the hepatic artery were tied at the same time, the urine contained a little albumin and hæmaglobin, together with small quantities of urobilin and biliary pigment, provided the gall-bladder had not been emptied before the operation. The quantity of urea was always greatly lessened if the hepatic artery were also tied, or the greater part of the liver removed. The relation of the nitrogen in urea to the total quantity of nitrogen excreted was much smaller than normal, being only 77 per cent. instead of 89 per cent. On the other hand, the uric acid in the urine ultimately increased in quantity, even when the hepatic artery was not tied, although the total quantity of nitrogen excreted was not greater than normal, the increase in the uric acid corresponding to the setting in of the convulsions. With regard to the ammonia contained in urine, the authors have come to the following conclusions:—(1) Eck's operation, combined with the ligature of the hepatic artery, causes in dogs an increase in the excretion of ammonia. In some cases this increase is relative only with regard to the nitrogen of urea or the total nitrogen, whereas in other cases it is absolute, and this absolute increase takes place when the animals survive the operation for twenty hours at least; (2) the secretion of ammonia increases rapidly in animals which have been subjected to Eck's operation as soon as the first symptoms set in.

In a further series of researches the authors showed that car-

[1] "Archives des Sciences biologiques publiés par l'institut impérial de médecine experimentale à St. Pétersbourg," vol. i. no. 4.

[2] "La fistule d'Eck de la veine cave inférieure et de la veine porte, et ses conséquences pour l'organisme, par MM. les Drs. M. Hahn, V. Massen, M. Nencki, et J. Pawlow."

bamic acid is present in the urine of a normal animal, and increases after Eck's operation. It would be interesting therefore to compare these facts with what we know of the increase of ammonia in pathological states of the liver in man. The liver, however, is not the only place where urea is formed, for the urea never completely disappeared in any of these experiments; and it is well known that in sharks which live seventy hours after the removal of the liver, the urea in the muscles does not diminish after the operation.

Such are the chief new facts we have met with in this interesting memoir, and it is certain that these investigations open up a new field for further researches. The other papers[1] contained in this volume call for little comment; they relate chiefly to the digestive and putrefactive processes taking place in the human intestinal tract.

It will be seen, however, that this fourth number sustains the well-earned reputation of the three first ones, and that the archives deserve to take their place among the chief scientific journals which made their first appearance in the year 1892.

STEAM ENGINE TRIALS.

A PAPER on the last series of steam-engine trials undertaken by the late Mr. P. W. Willans was read at the meeting of the Institution of Civil Engineers on April 11.

The paper dealt with an extensive series of condensing trials made with a 40 I.H.P. Willans Central-Valve Engine. These were intended to form a sequel to the investigations described in the author's papers, entitled "Economy Trials of a Non-condensing Steam Engine, Simple, Compound, and Triple," read before the Institution in 1888 and 1889. The principal objects in undertaking these trials were—(1) To ascertain the initial condensation in the first cylinder, and to trace the behaviour of the steam in the succeeding cylinders, when working as a compound or triple-expansion engine; (2) To observe the effect of speed of rotation, area of exposed surface, and range of temperature, upon the initial condensation, and upon economy generally; (3) To ascertain the percentage of the theoretical mean pressure actually obtained; (4) To ascertain the ratio of the work done by each pound of steam to the theoretical work due from it; (5) To determine the consumption of steam at all loads, and under various conditions.

The consumption of steam was determined by discharging the condensed water from the exhaust into a tank carried by a weigh-bridge, and observing the intervals of time required for fixed weights of water to run in. By this method, a continual watch was kept on the performance of the engine during the whole trial, and any disturbing cause was immediately detected; leaky steam-pipe joints did not affect the result, and the length of the trial might be much reduced. Special experiments, made to ascertain whether any addition was necessary to cover leakage in the engine and exhaust-pipe, showed that this leakage was slight.

The method of determining the theoretical work due from one pound of saturated steam when discharging into a condenser was next considered, and it was shown that the thermal efficiency of a condensing engine must of necessity be less than that of a non-condensing engine, owing to the greater proportionate size of the "toe" of the diagram cut off for practical reasons. In the non-condensing trials the best number of expansions was computed from the approximate formula $p^6 v^7 = \text{constant}$; but for the condensing trials the error in this could not be neglected. The best ratio of expansion and mean pressure were therefore calculated for adiabatic expansion, by Mr. Macfarlane Gray's $\theta\ \phi$ diagram, combined with a volume curve. Altogether sixty-two trials were made under various conditions of speed, steam-pressure, load, and ratio of expansion, as well as with the engine working simple, compound, and triple, and the results were embodied in the tables accompanying the paper.

One of the principal deductions from these experiments was the "straight-line" law of steam-consumption; and it was shown by diagrams that the *total* water for the horse-power corresponding to any mean pressure P, was W + K P., where W was the water which would be used by the engine at zero mean pressure (through initial condensation, radiation and conduction), supposing it were frictionless, and K was the water per hour required to produce each pound of mean pressure. These factors were shown to vary with the conditions under which the engine was working.

Eighteen of the trials were planned to assist in determining the law connecting initial condensation with revolutions; and it was found that in the high-pressure cylinder at high mean pressures the total condensation per unit of time was directly proportional to the square root of the number of revolutions per unit of time. As the mean pressure was diminished, the condensation became more and more nearly constant at all speeds; and finally, at low mean pressures, the law appeared to be reversed. For the low-pressure cylinder, the law was modified.

The important question of the changing proportions of steam and water present during the expansive part of the stroke was investigated by the $\theta\ \phi$ diagram. The matter was first examined theoretically by considering the effect of a thin liner of infinitely conducting matter, and a curve was drawn on the $\theta\ \phi$ diagram showing the rate at which the steam initially condensed in warming up the liner from the exhaust to the initial temperature was re-evaporated as the expansion proceeded. The actual re-evaporation, as obtained by measurement of the indicator cards was compared with this theoretical re-evaporation, the difference measuring the delay in the return of the heat from the liner to the steam. The losses due to conduction and radiation, to passage through ports, and to incomplete expansion, could also be shown on the $\theta\ \phi$ diagram.

The question of the economical advantage of reducing the power by automatic cut-off *versus* throttling was discussed. Broadly, the result was that the gain by varying the expansion was large for a simple engine, moderate for a compound engine, and, for a triple engine, almost inappreciable. It further appeared that the gain at high speeds was greater than at low speeds.

A few trials made with the cylinders steam-jacketed showed a slight gain, but further experiments were required to show whether the gain was likely to be worth the extra trouble and expense involved.

The missing steam at cut-off varied in the trials to even a greater extent than it did in the non-condensing trials—the amount being much affected by the range of temperature, the density of the steam, and by other conditions.

It appeared that, under all circumstances, the triple-condensing engine showed an advantage over the compound in regard to steam-consumption; but that, except for very large engines, the compound-transfer engine was probably the best for pressures below 150 lbs. (absolute) pressure per square inch.

ETHNOLOGICAL OBSERVATIONS IN AUSTRALIA.

SOME time ago Mr. R. Etheridge, jun., carried on a series of geological and ethnological investigations in the valley of the Wollondilly River, at its junction with the Nattai River, New South Wales; and in the latest number of the "Records of the Australian Museum" (vol. ii. No. 4) he gives an interesting account of the various facts he had occasion to study. The following is the greater part of the passage in which he records his ethnological observations:—

The aborigines of the Wollondilly and Nattai Valleys, must, from local accounts, have existed in considerable numbers, and are now only represented by interments, carved trees, wizards' hands, and charcoal drawings in rock shelters along the precipitous escarpments.

The first objects investigated under this head were the "Hands-on-the-Rock." The "rock" consists of a huge mass of Hawkesbury Sandstone, about seventeen feet in breadth and length, hollowed out on the side overlooking the river to the extent of six feet. It is perched on the side of a gentle rise from the Wollondilly, having rolled from the higher ground above, and alongside the track from the Nattai Junction to Cox's River, in the immediate south-west corner of the Parish Werriberri. The cavernous front of the rock is fifteen feet

[1] "On the Putrefactive Processes in the Large Intestine of Man and on the Microbes Causing Them," by M. Lumft. "On the Micro-organisms in the Organs of Choleraic Patients," by M. L. de Rekowski. "Contributions to the Study of Chemical Processes in the Intestines of Man," by M. Jakowski.

broad, and twelve feet high. On the back wall are depicted a number of red hands, both right and left. Under the principal hands are four white curved bands, resembling boomerangs or ribs, the whole of the hands being relieved, as is usually the case with these representations, by light splash-work. The hand-marks in this shelter differ, however, from any I have seen before by an unquestionably previous preparation of the rock surface for their reception by incising the surface to the shape of each hand, thus leaving a slightly raised margin around each. I have recently given (Records Geol. Survey, N.S. Wales, 1892, iii. Pt. i. p. 34) an epitome of our knowledge of these hand imprints, their method of preparation, and supposed significance sufficiently full to render any further reference unnecessary at present. The colour red, amongst black races, was the symbol of evil (Fraser, Journ. R. Soc., N.S. Wales for 1882 [1883], xvi. p. 213).

Mr. Maurice Hayes, of Queahgong, informed me that he has known the rock for the past fifty years, and that the imprints have not altered in the least. He found it difficult to obtain trustworthy information from the aborigines regarding them; they expressed ignorance, but ultimately gave him to understand that the "hands were the imprints of those of their Deity when on earth."

The large alluvial flats in this neighbourhood, along the Wollondilly, were, I was informed, great gathering grounds for the various tribes from many miles round, even those of Goulburn and Shoalhaven participating.

On a spur overlooking one of these green expanses, known as Gorman's Flat, immediately at the junction of the Wollondilly and Nattai Rivers, we investigated an interment, thirty years old, indicated by a single carved tree, but the device has, I regret to say, been wantonly destroyed. This grave is known to be that of "Jimmy Aremoy," or "Blackman's Billy," of the local tribe, and called in the aboriginal dialect *Ah-re-moy*, and was covered by a small mound at the foot of a small tree, forty-seven feet north of the carved tree, and had been surrounded by a sapling fence. After removing the mound and superincumbent soil, we found the grave had been filled with boulders and large pieces of rock to the depth of four feet six inches, whilst under this was a layer of split timber and bark. On removing this we found the skeleton well wrapt in what had once been an old coat, a blanket, and an opossum rug. The skeleton was doubled up in the usual manner, the arms drawn up to the breast, and the legs against the abdomen, placed on the right side, and facing the south-east. . . . Not the least interesting fact was the variety of articles placed with the deceased, according to aboriginal custom. Loose in the superincumbent earth we found an ingenious conversion of a piece of forked iron into a probable spear-head, a pointed stick, and some loose pieces of timber. Underneath the skeleton in various positions there occurred an old comb in two pieces, a thimble, a large iron spoon, the blade of another spoon, a small bullet mould, handle and portion of the tin-plate work of an old "quart-pot" or "billy-can," fragment of a clay tobacco pipe-stem, top of an old metal powder or shot case, containing shot and a few shirt buttons, and last, but by no means the least curious, a castor-oil bottle, still containing what seems to be a portion of the oil—this was placed directly under the head.

A little below the junction of the rivers we viewed the burial place of a "Chief" of the late local tribe, the interment having taken place about fifteen years ago. It lies contiguous to one of three marked trees placed in a triangle, the longest side or base of the latter being half a chain in length, and bearing north-west and south-east. The trees are still erect, although the carvings are more or less obliterated by bush fires, but they seem to have been chiefly in zig-zag lines, and of course cut with an iron tomahawk. The heavy rain prevailing at the time deterred us from investigating this burial.

This concluded our investigations in Burragorang proper, but on returning to Thirlmere, we diverted our course near Vanderville, across the Werriberri Creek to "The Hermitage," the estate of Mr. W. G. Hayes, parish of Burragorang, county of Camden. Through the kindness of Mr. Hayes we were allowed to examine a much more extensive burial ground than either of the preceding. Here, on a small plateau above and to the east of the Waterfall Creek, a branch of the Werriberri, and behind, or to the south of the homestead, are four graves of various sizes distinguished by four carved trees, more or less in a state of dilapidation. There does not appear to have been any geometrical form of arrangement assumed in the placing of these graves, unless it be a roughly rhomboidal one. We expected, from current report, to find five graves here, but four only rewarded our efforts. Three of the graves and three carved trees are more or less in a north-west and south-east line. Starting at the north-west corner, the figures on a She-oak (*Casuarina*) have been partially obliterated, ten feet from this is the first grave, and fourteen feet from the latter is another carved She-oak, now lying on the ground and much decayed. Fifty-one feet still further on occurs the largest grave, and at another fifty-one feet the third ornamented tree, a dead gum still standing but much burnt by bush fires, and bearing an extraordinary figure. Between the last grave and this tree, and deviating somewhat from the straight line in the third interment, at right-angles to the original starting point; and fifty-four feet from it at right angles, is the fourth carved tree, also a dead gum, bearing figures. At right angles to this again, and distant sixty-four feet, is the fourth grave, apparently without any indicating tree near it. We did not investigate the contents of these graves owing to want of time. . . .

I am not acquainted with any systematic account of Australian carved trees; in fact little seems to have been collectively written about them, and very few representations figured. Probably some of the earliest illustrations are those by Oxley, Sturt, and "W. R. G." presumed to be from the context of his writings, Mr. Surveyor W. R. Govett, of Govett's Leap fame. Oxley discovered a grave on the Lachlan, consisting of a semi-circular mound, with two trees overlooking it, barked and carved in a simple manner. (Journ. Two Expeds. Interior N.S. Wales, 1820, p. 139, plate). These carvings consisted of herring-bone on the one tree, and well-marked curved although simple lines on the other. The explorer Sturt noticed an oblong grave beyond Taylor's Rivulet, Macquarie River, around which the trees were "fancifully carved on the inner side," one with a figure of a heart (Two Expeds. Interior S. Austr., 1834, i., p. 14). The anonymous author (W. R. G.) describes an occurrence of this kind at Mount Wayo, County Argyle, in the following words:—"The trees all round the tomb were marked in various peculiar ways, some with zig-zags and stripes, and pieces of bark otherwise cut" (Saturday Mag. 1836, ix., No. 279, p. 184). A Mr. Macdonald states that the aborigines of the Page and Isis, tributaries of the Hunter River, carve serpentine lines on two trees to the north-west of each grave (Journ. Anthrop. Inst. Gt. Brit. and Ireland, 1878, vii., p. 256).

The figures are either composed of right lines or curves, more commonly the former, but a few instances have been recorded of natural objects, such as the outline of an Emu's foot, seen by Leichhardt on a gum tree in the Gulf Country (Journ. Overland Exped. Moreton Bay to Port Essington, 1847, p. 356). One thing is self-evident, such carvings possessed a dual if not a triple significance. We have already seen the employment of them to indicate an interment, presumably acting the part of a tombstone, for it is believed by some that the figures on a tree in each case correspond to those on the inner side of deceased's 'possum rug, the *mombarai*, or "drawing," which Fraser thinks was distinctive in each family, or a peculiar modification of the tribal *mombarai* (Journ. R. Soc. N.S. Wales for 1892 [1893], xvi., p. 201). So far as I can gather, such devices invariably indicated the last resting-place of a male. Mr. E. M. Curr states ("The Australian Race, 1886," ii., p. 433) that the Breeaba Tribe, at the head-waters of the Burdekin River, North Queensland, employed marked trees to commemorate a battle. He figures a tree from the banks of the Diamantina, barked and marked by a series of close, irregularly super-imposed notches, like those made by a black when climbing a tree. These, however, can hardly be compared to carvings.

According to Mr. J. Henderson, Dr. John Fraser, Mr. A. W. Howitt, and Mr. Macdonald previously mentioned, Bora Grounds are also embellished with carved trees. The first-named describes ("Obs. Colonies of N.S. Wales and V.D. Land," 1832, p. 145, pl. 3) the approach to one of these initiation places at Wellington as through "a long, straight avenue of trees, extending for about a mile, and these were carved on each side with various devices . . . At the lower extremity of this, a narrow pathway turned off towards the left, and soon terminated in a circle." Mr. Henderson further remarks that the fact of the use of this place for Bora purposes was communicated to him by the then headman of the tribe. Dr. Fraser says (Journ. R. Soc. N.S. Wales for 1882 [1883] xvi., p. 205) that the Gringai Tribe, one of the northern N.S. Welsh tribes, clear two circular enclosures, one within the other, for their Bora, and that the trees

growing around the smaller circle are carved "with curious emblematical devices and figures"; whilst Mr. Macdonald informs us that on the Bora ground of the Page and Isis River Natives, as many as a hundred and twenty marked trees occur round about (Journ. Anthrop. Inst. Gt. Brit. Ireland, 1878, vii., p. 256). Confirmation is further afforded by Mr. W. O. Hodgkinson, who saw a Bora ground on the Macleay River with "trees minutely tatooed, and carved to such a considerable altitude that he could not help feeling astonished at the labour bestowed on the work" (Smyth, "Aborigines of Victoria, 1878," i., p. 292).

If, as previously stated, according to current report, the designs on the trees be the same as those on the 'possum rugs, the transfer of them to the trees surrounding a grave must have had some important and lasting meaning to the survivors. The figures on the rug may have indicated some degree of ownership, a crest, coat of arms, or monogram, as it were, and in such a case the reproduction on the trees surrounding a grave may be looked upon as an identification of the deceased. Henderson speaks of the tree carvings as symbols. "A symbol is afterwards carved upon the nearest tree, which seems to indicate the particular tribe to which the individual may have belonged" ("Obs. Colonies of N.S. Wales and V.D. Land, 1832," p. 149). Or had they a deeper esoteric meaning, one only known to the learned men of the tribe? Smyth states ("Aborigines of Victoria, 1878," i., p. 288) that the figures on the inner sides of the 'possum rugs "were the same as those on their weapons, namely, the herring-bone, chevron, and saltier." How easily these same devices can be traced, in a general way, both on the carved trees and some of the wooden weapons, is amply shown by many of the excellent figures given in Smyth's work. This painstaking author, in briefly dealing—too briefly, in fact—with this interesting subject, says (*Ibid.* p. 286. The italics are mine): "The natives of the Murray and the Darling, and those in other parts adjacent, carved on the trees near the tombs of deceased warriors *strange figures having meanings no doubt intelligible to all the tribes* in the vast area watered by these rivers." By the Kamilarai (T. Honery, Journ. Anthrop. Inst. Gt. Brit. and Ireland, 1878, vii., p. 254) they were regarded as "memorials of the dead.

It is much to be regretted that before the last remnant of this fast-disappearing race has passed away, a translation, or at any rate an explanation of these matters, cannot be obtained.

SCIENTIFIC SERIALS.

American Journal of Science, April.—Distance of the stars by Doppler's principle, by G. W. Colles, Jun. This principle may be applied to the calculation of the distances of stars in the manner suggested by Fox Talbot and discussed by Prof. Rambaut. If the velocity of a component of a binary star be measured spectroscopically when it is moving in the line of sight, and its orbit be studied by means of the micrometer, the velocity at any point of the orbit, and hence also the size of the orbit, may be determined. This, divided by its angular magnitude, gives the distance of the system. From theoretical considerations the author calculates the ratio of the mean velocity across the line of sight of a large number of stars distributed equally over the celestial sphere to their mean velocity along the line of sight, and finds this ratio to be $\frac{\pi}{2}$. He then shows that the mean distance of all these stars will be approximately arrived at by multiplying this ratio by the sum of the observed velocities in the line of sight, and dividing by the sum of the observed corresponding angular velocities. Calculating from observations of ninety-five stars in the northern hemisphere, a mean distance of 150·9 light years is obtained, or, taking Vogel's observations only, 80·5 light years.—The radiation and absorption of heat by leaves, by Alfred Goldsborough Mayer. Two leaves of the same species of plant were each glued upon one of the polished tin sides of a Leslie cube. One of the leaves was then painted over with dead-black, and the cube was filled with water kept at 40° C. The radiation from the two leaves was measured by means of a thermopile. It was found that almost all the leaves radiated as well as lampblack. The effect of a thin film of dew was to reduce the radiation to 78 per cent, and to 66 per cent. if the dew stood out in beads upon the surface. The absorption of dark heat rays by leaves interposed as a diaphragm was found to be highly selective. A single elm leaf transmitted 20 per cent. of the radiant heat. A second leaf transmitted 78 per cent. of this, and a third over 83 per cent. of that transmitted by the second. Wild cherry leaves transmitted 9 per cent., and chicory 4 per cent. more heat when their chlorophyll was abstracted by ether or alcohol.—Also papers by Messrs. H. L. Wheeler, W. P. Headden, W. H. Melville, J. F. Kemp, E. A. Smith, R. T. Hill, M. I. Pupin, F. A. Gooch, and P. E. Browning.

THE most important article in the *Botanical Gazette* for December, 1892, is the one to which we have already alluded, in which Mr. R. Thaxter proposes the establishment of a new order of Schizomycetes with the name Myxobacteriaceæ. In that and the following numbers (January—March, 1893) Prof. D. H. Campbell gives his account, most of which we have reprinted, of his visit to the Hawaiian Islands; Mr. G. W. Martin completes his description of the development of the flower and embryo-sac in *Aster and Solidago*; Mr. F. B. Maxwell gives a comparative study of the roots of Ranunculaceæ, in which he makes three types of structure on the basis of the changes which take place through secondary growth. Mr. A. Schneider has a note on the influence of anæsthetics on the transpiration of plants; he finds that both this function and the vitality of protoplasm are both retarded by the action of ether, the protoplasm being finally killed. Prof. J. E. Humphrey gives a full account of the life-history of *Monilia fructigena*, a parasitic fungus which causes great destruction of pears and stone-fruit in America. In an article on non-parasitic bacteria in vegetable tissue Mr. H. L. Russell sums up his conclusion that vegetable, like animal tissues, are normally free from micro-organisms, but that in healthy vegetable tissues many species of bacteria are able to exist for a not inconsiderable length of time. We have also articles describing new species of flowering plants discovered on the American continent, and a *résumé* of the botanical papers read at the New Orleans meeting of the American Association for the Advancement of Science.

IN the numbers of the *Journal of Botany* from January to April the articles of most general interest, in addition to the continuation of others already noticed, are:—A list of the Mycetozoa of South Beds and North Herts, by Mr. Jas. Saunders; Dr. M. T. Masters, on some cases of inversion, in which he gives illustrations of the reversal of the normal relative position of organs or of elements of tissues; a provisional list of the marine algæ of the Cape of Good Hope, by Miss E. S. Barton; a list of the mosses of Guernsey, by Mr. E. D. Marquand; notes on Scotch freshwater algæ, by Mr. W. West, in which two new species are described; notes on the British species of *Campylopus*, a genus of Musci, by Mr. H. N. Dixon. Under the head of "Laboratory Notes," Mr. S. Le M. Moore describes the best way of making Millon's reagent; a new way of demonstrating continuity of protoplasm (Millon's fluid); and the action of cold Millon's fluid on iron-greening tannins, and on cell walls giving proteid reactions.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 2.—"A New Portable Miner's Safety-lamp, with Hydrogen attachment for delicate Gas-testing; with exact Measurements of Flame-cap indications furnished by this and by other Testing-lamps." By Prof. Frank Clowes, D.Sc. (Lond.), University College, Nottingham.

The author, availing himself of his "test-chamber," already described in the Proc. Roy. Soc. vols. l. li. has examined the indications of fire-damp furnished by the different safety-lamps at present in use for testing purposes. These lamps include the ordinary oil-lamp, the Pieler alcohol lamp, the Ashworth benzoline lamp, and the hydrogen-oil lamp, recently devised by the author.

The introduction of a standard hydrogen gas-testing flame into an ordinary oil safety-lamp was first effected by the author, and was described by him in the papers referred to above. But it has now been brought into a far more convenient and portable form; the most recent development of the lamp is described and explained by illustrations in the present paper. The hydrogen gas is stored in a little pocket steel cylinder, under about 100 atmospheres pressure: this can be immediately attached to the safety-lamp when required, and can be made to furnish a standard 10 millimetre hydrogen flame which will burn continuously for forty minutes from the cylinder-supply. The hydrogen is kindled from the oil-flame, without opening the

lamp: and proves to be equal in delicacy and accuracy of testing to Liveing's indicator and other forms of apparatus of precision at present in use. The lamp presents the great advantage of serving at once for lighting, for ordinary gas-testing by the oil-flame, and for most accurate and delicate testing by means of the hydrogen flame.

The paper gives full statements of the results of the flame-cap measurements of the new lamp, and of the lamps mentioned above.

The general conclusions to be drawn from these measurements, and from experience derived from working with the different lamps, are the following:—

(1) The indications of the Pieler lamp begin at the lowest limit of 0·25 per cent., but quickly become too great to be utilised. The thread-like tip extending above the flame for several inches in pure air must not be mistaken for a cap, but it is scarcely distinguishable from the cap given by 0·25 per cent. of gas.

This lamp suffers under the disadvantage that much of the feeble light of the caps is lost by the obstruction of the gauze: the gauze also frequently presents a bright reflecting surface behind the flame, and this renders the observation of the cap impossible. All the other lamps in use are free from these interferences due to the gauze, and if their glasses are blackened behind internally by smoking them with a taper they become well suited for the observation of caps.

(2) The Ashworth benzoline lamp begins its indications doubtfully at 0·5 per cent., the cap thus produced being more distinct, but not greater in height, than the mantle of the flame seen in gas-free air.

But starting with certainty with an indication of 1 per cent., it gives strikingly regular indications up to 6 per cent., and even higher percentages may be read off in a lamp with a long glass.

(3) The standard 10 mm. hydrogen flame gives distinct indications from 0·25 to 3 per cent.; the cap then becomes too high for measurement in the lamp; but by reducing the flame to 5 mm., cap readings may be taken up to 6 per cent. of gas.

The lower indications may similarly be increased by raising the flame to 15 mm.

(4) The oil flame produced by unmixed colza oil gives no indications with percentages below 2. With 1 per cent. of gas the flame from colza mixed with an equal volume of petroleum (water-white) produces an apparent cap, which, though somewhat more intense than the natural mantle seen in gas-free air, is only equal to this mantle in dimensions, and might easily be mistaken for it.

The oil flame, when it is reduced until it just loses its luminous tip, however, gives distinct indications from 3 to 6 per cent.

The largest indications are produced by drawing down the flame *in the presence of the gas*, until a cap of maximum size is obtained.

A carefully regulated oil flame may, therefore, conveniently supplement the hydrogen flame for the indication of gas varying from 3 to 6 per cent., and in the new hydrogen lamp this will be found to be a convenient method to adopt.

The use of colza alone in the oil-lamp is very inconvenient for gas-testing: the wick quickly chars and hardens on the top, and cannot then be reduced without danger of extinction; it can never be obtained satisfactorily in a non-luminous condition. The admixture with petroleum obviates these difficulties.

The use of the hydrogen flame for gas-testing has been proposed, but has never been hitherto carried into practice in an ordinary safety lamp. Careful comparison proves this flame to be superior to the alcohol flame and to all other flames at present suggested. Its indications have never been carefully observed and measured before; they are carefully summarised in the present paper.

It will be readily understood that the main advantages resulting from the use of the hydrogen flame are the following:—

(1) The flame is non-luminous, whatever its dimensions may be, and therefore does not interfere with the perception of the cap.

(2) The flame can always be adjusted at once to standard height and maintained at that height sufficiently long for the completion of the test; whereas other testing flames are constansly varying in dimensions, and most of them cannot be set to standard size at all with any certainty.

Thus a colza-petroleum flame exposed in air containing a low percentage of gas when twice adjusted gave caps of 8 and of 20 mm. The reduced oil flame often fell so quickly that cap-readings with low percentages of gas could not be taken at all.

(3) The caps produced over the hydrogen flame are larger than those produced by any flame of corresponding size.

(4) The size of the hydrogen flame can therefore be so far reduced as to enable it to be used in an ordinary safety-lamp.

The size of the flame may further be suitably varied so as to increase or decrease the height of the cap and thus either increase the delicacy of the test or extend its range.

(5) The hydrogen flame shows no trace of mantle or cap in air free from gas; it resembles the Pieler flame in showing only a slender thread above its apex. The colza-petroleum and the benzoline flames show pale mantles in gas-free air, which may be easily mistaken for a small percentage of gas.

(6) The standard hydrogen flame burns vigorously, it is of fair size, and cannot be extinguished by accident; whereas the reduced flames ordinarily used in testing burn feebly and are readily lost.

(7) Hydrogen is supplied pure and of practically invariable composition; whereas oil and alcohol are apt to vary much in composition, and therefore to give flames whose indications vary with the sample of liquid which is being burnt.

It should be noted that the hydrogen flame is set to standard size *in the presence of the gas*, and therefore yields accurate indications in any atmosphere in which the test is made.

The paper gives full descriptions of the method pursued for obtaining accurate flame-cap measurements in this research. The indications furnished by the new lamp in air containing coal-gas and water-gas are also tabulated; and it is shown that these gases are readily detected when present in small proportions in the air, and their amount is accurately determined. The lamp shows equal delicacy and accuracy in the detection and estimation of petroleum vapour in the air.

When used for the detection of fire-damp the amount of fine coal-dust ordinarily present in the air of the mine caused no interference with the test. The lamp had been proved by use in the coal-mine to be thoroughly practical and easy in its application to gas-testing.

February 16.—"Further Experiments on the Action of Light on *Bacillus anthracis*." IV. By H. Marshall Ward, D.Sc., F.R.S., Professor of Botany, Royal Indian Engineering College, Coopers Hill.

The author has continued his experiments, proving that the light of a winter sun and that of the electric arc rapidly destroy the life of the spores of the anthrax bacillus, and showing that the bactericidal action is really direct, and not due to elevation of temperature, or to any indirect poisoning or starving process incident on changes in the food materials. The evidence goes to prove that the effect is chiefly if not entirely due to the rays of higher refrangibility in the blue-violet of the spectrum.

The experiments have been continued with special reference to these latter points, and confirm the general conclusions in every detail. Not only so, but the further results prove that the inhibitory and deadly effects of direct insolation are not confined to *Bacillus anthracis*, but also extend to other bacteria and even to the Fungi; and throw some light on several problems which have presented themselves during previous investigations.

Experiments with Coloured Screens of Various Kinds.

The author described experiments made during December to February with coloured screens of various kinds; premising that the methods employed in preparing and exposing the plates, &c., have been the same as those referred to in the previous communication.

The results show that when plates are exposed for equal periods behind screens transmitting blue and violet rays, and behind screens which cut off those rays, the spores on the former are killed, whereas no bactericidal action occurs on the latter.

Experiments with Spores and Food Material on Separate Plates.

In order to test still further the accuracy of previous conclusions, that the bactericidal action of the sunlight is direct,

and not due to secondary effects, owing to changes in the food material, the following modifications of the experiments were carried out, and yielded most important and conclusive proofs that the *action of the rays of light is direct on the spores*, and not due to secondary actions owing to changes in the food materials.

Two plates, for instance, of dried spores only are made, and two of agar only, all as before. Then one plate of each kind is exposed to the light, and the others are kept in the dark.

After exposure, the stiff and moist film of *non-exposed* agar is removed from its own plate, and *superposed on the exposed film of dried spores in situ*. Reciprocally, the film of *exposed* agar *is removed*, and *superposed on the non-exposed film of dried spores*.

This prevents any wash or displacement, and ensures at the same time that the agar shall present in contact with the spores that face which was next the source of light.

So far no appreciable effect on the agar has been observed, though the dried spores exposed for an equal period are killed in abundance, as shown by the figure which comes out on culture.

Preliminary Results with the Spores of Fungi.

Results substantially the same as the above are obtainable with other *Schizomycetes*, but it was interesting to see whether anything of kind occurs with the spores of true Fungi. The time of year has, for many reasons, been unfavourable for very numerous experiments, but the results so far are extremely encouraging, and should give a stimulus to close inquiry into the whole subject.

The following species have been examined:—*Penicillium crustaceum*, *Aspergillus glaucus*, *Botrytis cinerea*, *Chalara mycoderma*, *Oidium lactis*, *Nectria cinnabarina*, *Mucor racemosus*, *Saccharomyces pyriformis*, and a "*Stysanus*" conidial form met with some months ago as a saprophyte on *Pandanus*.

On making agar and gelatine plates of these as before, positive results were obtained with *Oidium* (5 cases), *Chalara* (1 case), *Saccharomyces* (4 cases), *Stysanus* (2 cases), and negative results with *Aspergillus* (5 cases), *Penicillium* (2 cases), *Mucor* (2 cases), *Nectria* (4 cases), and *Botrytis* (2 cases).

It seems worth noting that, in all the forms which have given a positive result right off, the spores, as seen in masses, are either hyaline and colourless, or, in the case of the *Stysanus*, with a faint tinge of buff; whereas those which gave negative results are either of some very pronounced colour, as *Aspergillus*, *Penicillium*, and *Nectria*, or (*Mucor* and *Botrytis*) of a dull, yellow-brown hue.

After some theoretical considerations, some practical bearings of the results are thus referred to:—

The establishment of the fact of the bactericidal and fungicidal action of light, dating from Downes and Blunt to now, enables us to see much more clearly into the causes of several phenomena known to practical agriculturists, foresters, hygienists, &c.

It helps to explain, for example, why the soil of a forest should not be exposed to the sun, a dogma long taught in schools; it will also effect our way of regarding bare fallows. It has already been shown how important is its bearing on the purification of rivers, and the reasoning obviously applies to dwellings, towns, &c. The author regards it as probably explaining many discrepancies in the cultures of Schizomycetes and Fungi in our laboratories, and as having a very important bearing indeed on the spreading of plant epidemics in dull weather in the summer, and no doubt this applies to other cases.

That sunshine has something to do with the rarity of bacterial diseases in plants now seems quite as probable as the currently accepted view that the acid nature of the latter accounts for the fact.

If that part of the chlorophyll which absorbs the blue-violet is a screen to prevent the destruction of easily oxidisable bodies, as they are formed in the chloroplasts, we may reconcile several old experimental discrepancies—*e.g.* the behaviour of plants under bichromate and cupric oxide screens.

The author concludes from his experiments, and from numerous other considerations given in the paper, that the colours of spores, pollen grains, &c., are of the nature of colour-screens, and is led to put forward the following hypothesis:—

No plant exposes a reserve store of fatty food materials to the danger of prolonged or intense insolations without a protective colour-screen, calculated to cut out at least the blue violet rays, as these rays would otherwise destroy the reserve substance by promoting its rapid oxidation.

"Studies in the Morphology of Spore-producing Members. Preliminary Statement on the Equisetaceæ and Psilotaceæ." II. By F. O. Bower, D.Sc., F.R.S., Regius Professor of Botany in the University of Glasgow.

Still maintaining the same general views as were put forward in my preliminary statement on the Lycopodinæ and Ophioglossaceæ (Roy. Soc. Proc., vol. l. p. 265), I have now investigated other types from among the Vascular Cryptogams as regards the development of their spore-producing members.

Taking first the Equisetaceæ, the development of the sporangia has been closely followed by Goebel; I find it, however, difficult to accept his conclusions as to the hypodermal origin of the archesporium. On following the early phases of development in *Eq. arvense*, the sporangium is found to be eusporangiate, but the essential parts of the sporangium may be traced in origin to a single superficial cell, the cells adjoining this laterally contributing only to form the lateral portions of the wall. The first division of this cell is periclinal: *the inner resulting cell forms only a part of the sporogenous tissue;* the outer cell undergoes further segmentation, first by anticlinal, then by periclinal, walls, and *the inner cells thus produced are added to the sporogenous tissue, and take part in spore-formation.* The archesporium of *Eq. arvense* is thus shown to be not of hypodermal origin in the strict sense; the same appears to be the case in *Eq. limosum*. Similar additions to the sporogenous tissue by early periclinal division of superficial cells is commonly to be seen in *Isoetes*, and occasional cases, which are difficult to explain in any other way, have been observed in some species of *Lycopodium*. It would thus appear that Goebel's generalisation, that in all the Vascular Cryptogams which he investigated a hypodermal archesporium exists, cannot be retained in the strict sense. The tapetum is derived from the series of cells immediately surrounding the sporogenous mass; it is, however, to be carefully distinguished from certain cells of the sporogenous mass, which also undergo an early disorganisation; for about one-third of the cells of the sporogenous mass do not form spores, but serve physiologically as a diffused tapetum, yielding up their substance to nourish the other young developing spores.

The synangia of the Psilotaceæ have given rise to voluminous discussions. *Tmesipteris* being the genus with the simpler structure, it may be described first. In their earliest stages of development, as lateral outgrowths from the axis, the sporangiophores are not readily distinguishable from the foliage leaves in form or structure, while they occupy a similar position upon the axis. The first appearance of a synangium is as an upgrowth of superficial cells of the adaxial face of the sporangiophore, immediately below its apex; meanwhile the cells of the abaxial side also grow strongly, while the apex itself does not grow so rapidly; so that the organic apex is soon sunk in a groove between these stronger growths. The superficial cells which are to form the synangium undergo periclinal and anticlinal divisions, to form about four layers of cells. All the cells of this tissue are at first very similar to one another, but later two sporogenous masses become differentiated; they are not, however, clearly defined while young from the sterile issue which forms the partition of the synangium, or from the wall. From the arrangement of the cells of these sporogenous masses it seems not improbable that each mass may be referable in origin to a single cell, but this has not been proved to be constantly the case. All the cells of the sporogenous tissue do not arrive at maturity, but here, as in *Equisetum*, a considerable number, serving as a diffused tapetum, become disorganised without forming spores. There is no clearly-defined tapetum in *Tmesipteris*. The leaf lobes begin to be formed almost simultaneously with the synangium, and appear as lateral growths immediately below the apex of the sporangiophore; their further development presents no characters of special note.

The synangium of *Psilotum* originates in essentially a similar manner, being formed from the upper surface of the sporangiophore, immediately below its apex.

On the ground of the observations of internal development, of which the above are the essential features, I agree with the conclusion of Solms that the whole sporangiophore of the Psilotaceæ is of foliar nature, and that the synangium is a growth from its upper surface.

In *Lepidodendron* the sporangium is very large; it is narrow and elongated in a radial direction, extending a considerable distance along the upper surface of the leaf. I have already communicated to the Society the fact that trabeculæ extend in *Lepidodendron* from the base of the sporangium far up into the mass of

spores, and have compared these with the trabeculæ in the sporangium of *Isoetes*. Neither of these sporangia are, however, completely partitioned. I now suggest that comparatively slight modification of the condition in *Lepidodendron* would produce the state of things seen in *Tmesipteris*: if the sterile trabeculæ of *Lepidodendron* were consolidated into a transverse septum, and the apical growth of the sporophyll arrested and taken up by two lateral lobes, the result would be such as is seen in *Tmesipteris*. This is not a mere imaginative suggestion: it proceeds from the observed fact that the septum in *Tmesipteris* is indistinguishable at first from the sporogenous masses. It may further be noted, in connection with the above comparison between *Lepidodendron* and *Tmesipteris*, that the vascular tissues of some of the former appear to correspond more closely to those of *Tmesipteris* than to any other living plant.

Looking at the whole plants of the Psilotaceæ from the point of view above indicated, they are to be regarded as lax strobili, bearing sporangiophores (sporophylls) of rather complex structure. Branching, which is rare in *Tmesipteris*, is common in *Psilotum*, and is to be compared with the branching of the strobilus in many species of *Lycopodium*. In both there are irregularly alternating sterile and fertile zones, not unlike those of some species of *Lycopodium*; at the limits of these arrested sporangia are frequently found. It is not difficult to imagine how such plants as the Psilotaceæ may have originated from some strobiloid type, not unlike that of the genus *Lycopodium*.

March 23.—"The Absolute Thermal Conductivities of Copper and Iron." By R. Wallace Stewart, B.Sc. (London), Assistant Lecturer and Demonstrator in Physics, University College, Bangor. Communicated by Lord Kelvin, P.R.S.

The experiments described in the paper were undertaken with the object of determining the thermal conductivity at different temperatures of iron, and, in particular, of pure, electrolytically deposited copper.

The method adopted was that due to Forbes, but the thermo-electric method of determining temperature was employed, and the bar was protected from currents of air and external radiation by surrounding it by a trough of sheet zinc.

The iron bar used was a square $\frac{3}{4}$-inch bar of ordinary wrought iron; the copper bar was a round $\frac{1}{2}$-inch bar of pure electrolytic copper.

The variation of the specific heat of iron with the temperature was determined by Bunsen's calorimeter; for the specific heat of copper the result given by Bède was taken.

The range of temperature over which the observations extended was from 15° C. to about 220° C.

The final results obtained are indicated by the formulæ given below, and tend to show that for both copper and iron the conductivity decreases with rise of temperature.

Results for Iron in C.G.S. Units.

Diffusivity, κ, at $t°$ C. is given by—

$$\kappa_t = 0{\cdot}208\,(1 - 0{\cdot}00175t),$$

and the absolute thermal conductivity, k, by—

$$k_t = 0{\cdot}172\,(1 - 0{\cdot}0011t).$$

Results for Copper in C.G.S. Units.

Diffusivity, κ, at $t°$ C. is given by—

I. $\kappa_t = 1{\cdot}370\,(1 - 0{\cdot}00125t)$.

II. $\kappa_t = 1{\cdot}391\,(1 - 0{\cdot}00120t)$.

The mean of these results is taken as—

$$\kappa_t = 1{\cdot}38\,(1 - 0{\cdot}0012t),$$

and the value of the absolute conductivity, k, is then given by—

$$k_t = 1{\cdot}10\,(1 - 0{\cdot}00053t).$$

A table is given at the end of the paper showing the emissive power of the surface of each bar at temperatures between 20° C. and 200° C.

Linnean Society, April 6.—Prof. Stewart, President, in the chair.—The President took occasion to refer to the great loss which botanical science had sustained by the death, on April 4, of Prof. Alphonse de Candolle of Geneva, an announcement which was received with profound regret. Prof. de Candolle was the senior foreign member of this Society, having been elected in May 1850, and was the recipient of the Society's Gold Medal in 1889.—Mr. Clement Reid exhibited and made some remarks upon the fruit of a South European Maple (*Acer monspessulanum*) from an interglacial deposit on the Hampshire coast.—Mr. R. Lloyd Præger, who was present as a visitor, exhibited some rare British plants from the co. Armagh, and gave an account of their local distribution.—A paper was then read by Mr. W. B. Hemsley on a collection of plants from the region of Lhassa, made by Surgeon-Captain Thorold in 1891, and a further collection from the Kuenlun plains made by Captain Picot in 1892. Some of the more interesting plants were exhibited, and critical remarks were offered by Messrs. C. B. Clarke, J. G. Baker, and Dr. Stapf.—Dr. H. C. Sorby gave a demonstration with the oxyhydrogen lantern and exhibited a number of slides which he had prepared of small marine organisms, many of them extremely beautiful, mounted transparently so as to show the internal structure.

Entomological Society, April 12.—Mr. Frederic Merrifield, Vice-President, in the chair.—Sir John T. Dillwyn Llewelyn, Bart., exhibited a number of specimens of Lepidoptera, Coleoptera, and Hymenoptera, all caught in Glamorganshire. The Lepidoptera included two remarkable varieties of *Vanessa io*, both obtained from the same brood of larvæ from which the usual eye-like spots in the hind wings were absent; varieties of *Arctia menthastri*; a long series of melanic and other forms of *Boarmia repandata* and *Tephrosia crepuscularia*; and bleached forms of *Geometra papilionaria*. The Coleoptera included specimens of *Prionus coriarius*, *Pyrochroa coccinea*, *Otiorhynchus sulcatus*, and *Astynomus ædilis*, a large species of Longicornia, which Sir John Llewelyn stated had been handed to him by colliers, who obtained them from the wooden props used in the coal mines, made out of timber imported from the Baltic. Mr. Merrifield, Dr. Sharp, F.R.S., and Mr. Stevens made some remarks on the specimens.—Sir John T. D. Llewelyn inquired whether the name of the moth which had a sufficiently long proboscis to fertilise the large Madagascan species of Orchis, *Angræcum sesquipedale*, was known. Mr. C. O. Waterhouse stated that the collections received at the British Museum from Madagascar had been examined with the view to the discovery of the species, but up to the present it had not been identified.—Mr. H. Goss exhibited, for Mr. Frank W. P. Dennis, of Bahia, Brazil, several nests of Trap-door Spiders, containing living specimens of the spider, and read a communication from Mr. Dennis on the subject. Several photographs of the nests and the spiders were also exhibited. It was stated that Mr. Dennis had found these nests at Bahia in one spot only in a cocoa-nut grove close by the sea.—Mr. McLachlan, F.R.S., read a paper entitled "On species of Chrysopa observed in the Eastern Pyrenees; together with descriptions of, and notes on, new or little-known Palæarctic forms of the genus." The author stated that the species referred to in this paper had been observed by him in the Eastern Pyrenees, in July, 1886, when staying with Mons. René Oberthür. After describing the nature of the district, and its capabilities from an entomological point of view, the paper concluded with descriptions of certain new palæarctic species of the genus. Dr. Sharp, who said that he was acquainted with the district, and Mr. Merrifield made some remarks on the paper.

PARIS.

Academy of Sciences, April 10.—M. Lœwy in the chair.—The deaths were announced of Vice-Amiral Pâris and M. Alphonse de Candolle.—On the extinction of torrents and the replanting of the highlands, by M. P. Demontzey. A report on the work done since 1883 towards securing the south of France from its periodical inundation by mountain torrents.—On the loss of electric charge in diffused light and in darkness, by M. Édouard Branly.—Dynamo-electric machinery with compound excitation, by M. Paul Hoho. If a curve be constructed showing how the magnetic excitation of a dynamo-electric machine ought to vary in order that the E.M.F. may remain constant, or may vary according to a given law, it is possible to contrive an excitation such that, if it be also expressed by a curve, the latter will cut the former in any number of points required. Between these points of intersection the two curves nearly coincide. Hence it is possible to produce currents which, between certain limits, do not vary with the speed of the engine. This has been practically realised by means of two separate exciter circuits.—On anomalous dispersion, by M. Salvator Bloch.—General conditions to be fulfilled by registering instruments or indicators; problem of integral synchronisation, by M. A. Blondel. All the instruments in question consist essentially of a movable piece (needle, pencil, membrane, or mirror) susceptible of rectilinear or circular displacement under the simultaneous influence of a

force proportional to the physical quantity to be measured, an opposing force sensibly proportional to the displacement, the inertia of the moving parts, and the damping force, usually proportional to the velocity. The desideratum is that the periodic motion of the moving piece should follow a law as closely approaching that of the phenomenon as possible, so that the deflection may at any instant depart as little as possible from a value equal to the ratio of the force to be measured and the opposing force. This the inventor of the "oscillograph" calls the problem of integral synchronisation, from its analogy to that of simple synchronisation investigated by M. Cornu.—An expression is given for the value below which the damping effect, though made as small as possible, should not be allowed to fall.—On the volatility of manganese, by M. S. Jordan.—Determination of atomic weights by the limit method, by M. G. Hinrichs.—On nitrogenised copper, by MM. Paul Sabatier and J. B. Senderens. Several metals, when newly prepared by means of reduction of their oxides by hydrogen, are able to fix a large quantity of nitrogen peroxide in the cold. The resulting compounds have been termed nitrogenised metals (*métaux nitrés*). In the case of copper, a quantitative analysis of the compound has led to the formula Cu_2NO_2, which corresponds to the fixation upon the metallic surface of the copper of about 1000 times its volume of peroxide at 30° C.—On the isomerism of the amido-benzoic acids, by M. Oechsner de Coninck.—On phtalocyanacetic ether, by P. Th. Muller.—On transpiration in herbaceous grafts, by M. Lucien Daniel.—Exploration of the higher atmosphere; experiment of March 21, 1893, by M. Gustave Hermite. The balloon carrying the registering instruments was constructed of triple gold-beater's skin varnished, its volume being 113 cubic metres. The total weight of the apparatus carried was 17 kgr., including an automatic distributor of inquiry cards, working by a fuse. The ascensional force was 65 kgr., giving a vertical velocity of 8 or 9m. per second. The average velocity of descent was 2·4m., so that the instruments did not suffer. The balloon ascended at 12h. 25m. from Paris-Vaugirard, and landed at Chanvres (Yonne) at 7h. 11m. p.m. The lowest pressure registered was 103 mm., or less than one-seventh of an atmosphere, which corresponds to a height of about 16,000 m. The lowest temperature recorded was −51° C. at 12,500 m., after which the curves of temperature and pressure were interrupted by the freezing of the recording ink. Subsequently, however, the intense solar radiation seems to have thawed the ink, so that the barometric record was taken up again at 16,000 m. and the thermometric curve at −21° C. The fuse ceased to burn after some time, probably owing to the lack of oxygen. The balloon could be followed with the naked eye for three-quarters of an hour, within which it attained its highest altitude. It was white, and brightly illuminated by the sun.—Odoriferous power of chloroform, bromoform, and iodoform, by M. Jacques Passy.—Observations on a series of new forms of snow, collected at very low temperatures, by M. Gustave Nordenskiöld.

BERLIN.

Physiological Society, March 17.—Prof. du Bois Reymond, President, in the chair.—In the discussion which ensued on the communication made at the last meeting of the society, Prof. Zuntz gave the data as to the daily consumption of proteid and fat by the fasting man Cetti, as also the heat produced by their oxidation, from which it appeared that the heat production during his fast was constant.—Prof. Behring gave an account of his further experiments with preventive serum. A portion was mixed with a slight excess of tetanus virus; mice died after inoculation with the mixture. When heated to 65° C. the virus became inert, but not so the serum, thus proving that the respective substances had not exerted any chemical action each on the other. A further new and important fact observed was that tetanus virus—that is, the products of metabolism of tetanus bacilli—made inert by heating to 65° acts preventively towards tetanus infection. Hence the facts known to hold good as to the action of tuberculin in tuberculosis now appear to hold good with regard to tetanus, and should be further investigated in the case of other acute diseases, such as diphtheria, typhus, and cholera.—Dr. Lewy-Dorn gave a full description of his experiments on the question of whether the formation of sweat is the result of a filtrational process. By calculating the capacity of the sweat-glands, and the volume of the sweat-drops secreted, he came to the conclusion that a true new formation of sweat could only be assumed with certainty after a fourfold and copious secretion had taken place. When he now subjected the foot of a cat to an air-pressure far exceeding that of the blood, secretion of sweat was observed on stimulation of the sciatic nerve. On the other hand, when the foot was subjected to a considerably reduced (negative) air-pressure, no formation of sweat was observed. Both these facts are opposed to the filtrational theory of sweat-secretion. Varnishing the skin did not prevent the secretion of sweat resulting from stimulation of nerves or administration of pilocarpine.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

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PAMPHLETS.—Bibliography of the Athapascan Languages: J. C. Pilling (Washington).—A List of some of the Rotifera of Ireland: Miss Glascott (Dublin).

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