THURSDAY, JANUARY 11, 1894.

THE KEW INDEX OF PLANT-NAMES.

Index Kewensis plantarum phanerogamarum nomina et synonyma omnium generum et specierum a linnaeo usque ad annum mdccclxxxv complectens nomine recepto auctore patria unicuique plantae subjectis. Sumptibus Caroli Roberti Darwin, ductu et consilio Josephi D. Hooker, confecit B. D. Jackson. Fasciculi II. (Oxonii: E prelo Clarendoniano, MDCCCXCIII.)

THE appearance in rapid succession of the first two fasciculi forming the first volume of this splendid work, to be fittingly known to all time as the "Index Kewensis," is an event of supreme importance not only to the widely limited section of the scientific world which is professedly botanical, but also to the much wider circle of those who are interested in plants, whether this be from their more strictly technical side as the source of economic products, or from their more general and popular one, as objects of pleasure in cultivation and decoration. With the completion of the work in the second volume, which we are glad to know is not likely to be delayed beyond the current year, everyone will have within reach a book of reference in which may be found the correct name, the synonymy, the authority for the name, and the title of the work in which it is first published, along with an indication of the native country of any flowering plant described before the end of the year 1885.

It is to Charles Darwin we owe primarily this valuable work. In a short preface to the first fasciculus, Sir Joseph Hooker gives the following concise narrative of its origin:

"Shortly before his death Mr. Darwin informed me of his intention to devote a considerable sum in aid or furtherance of some work of utility to biological science; and to provide for its completion, should this not be accomplished during his lifetime. He further informed me that the difficulties he had experienced in accurately designating the many plants which he had studied, and ascertaining their native countries, had suggested to him the compilation of an index to the names and authorities of all known flowering plants and their countries, as a work of supreme importance to students of systematic and geographical botany, and to horticulturists, and as a fitting object of the fulfilment of his intentions.

"I have only to add that, at his request, I undertook to direct and supervise such a work; and that it is being carried out at the herbarium of the Royal Gardens, Kew, with the aid of the staff of that establishment."

Everyone who has had dealings with plants will have realised the difficulties referred to by Mr. Darwin, and will welcome the issue of the "Index Kewensis" to which his munificence has given birth, and will congratulate Sir Joseph Hooker and Mr. Daydon Jackson on the result of their fifteen years' labour as the instruments through which the practical wish of Mr. Darwin is in process of being carried out. In passing, it is not uninteresting, from the point of view of history, to note the association of the name of Darwin with this Index. The biological sciences, whilst owing an eternal debt of gratitude to Linnæus for the order which he brought out of their preceding chaos, and for the binomial nomenclature his genius so deftly constructed as an alphabet of system, have reason to regret the retarding influence on their progressive development of the dogma of constancy of species which his scholasticism tacked on to his nomenclature, and which the nomenclature served to perpetuate. From the trammels of this dogma the genius and work of Darwin gave to biology final emancipation, and now by his forethought and munificence this enumeration of genera and species is being provided, the foundation of which rests on the enduring portion of the work of the great Swedish naturalist.

It is impossible to emphasise too strongly the value of the book before us. The most recent work of similar kind is the "Nomenclator Botanicus" of Steudel. But this was completed in 1841, and since that date the activity of botanists and the exploration of the world's surface has added so enormously to the known plants, that for practical purposes Steudel's Nomenclator has been for long out of date. The "Index Kewensis" is not, however, cast on quite the same lines as Steudel's work, and possesses valuable features absent from it. The Nomenclator was confessedly a critical botanical book, expressing the views of the limitation and relationship of genera and species held by the author, and consequently new names on the authority of Steudel occur throughout. The "Index Kewensis" makes no such profession. It takes the literature as it existed at the end of the year 1885, and from it is compiled, in conformity with certain definite guiding principles of plant-naming, the correct nomenclature, based, so far as the limitation of genera and species is concerned, upon the work of the most competent and trustworthy writers. The "Genera Plantarum" of Bentham and Hooker gives the standard of limitation of genera, and for species the conclusions of monographers and recognised authorities in the different groups supply the basis for the synonymy. The Index is therefore essentially a literary work carried out under effective botanical supervision, and the circumstances surrounding its production are most favourable. No one more qualified for this detailed work than Mr. Daydon Jackson, by his extensive knowledge of botanical literature and critical judgment, could have been found; in Sir Joseph Hooker the work has the supervision of the most experienced systematic botanist of the day; and Kew, the natural birthplace of a British book dealing with all flowering plants, affords unrivalled facilities for the investigation involved in such a work.

We have said the "Index Kewensis" gives the correct name of all plants described before the end of the year 1885. This brings up the much-discussed question of what is the correct name of a plant? Under what rules is it to be fixed? In its bearing on this question the Index appears most opportunely, and it may be regarded as the manifesto of the working British systematic botanists upon the vexed subject of plant-nomenclature; and a thoroughly practical one it is. Briefly the guiding rules of the Index are these:—The starting point for genera is the first edition of the "Systema" of Linnæus, published in 1735; the starting point for species is the first edition of the "Species Plantarum" of Linnæus, published in 1753; the correct name is that given by the author who first placed the plant in its proper genus. There is a soundness in these principles which should

appeal to any unprejudiced mind. If nomenclature dates from Linnæus, who founded the system, naturally the first editions of his works dealing satisfactorily with genera and with species, are respective points of departure for the names of these, and in dealing with the species described by subsequent authors a similar course must be pursued. This code has been the tradition of the representative British botanists, and to it the former leaders of American botany also subscribed. It is the simple rule that priority determines the name. But, as with other rules framed by frail humanity for its guidance, this, if applied with rigorous inflexibility, would defeat the object it is designed to serve. To drop a name which has become generally accepted as the designation of a plant, and with which it is always associated, and take up for it some unknown name, simply because some one has discovered that this one preceded that by a few months in publication, or because it occurs a few lines earlier on the page of the same work, may mean logical adherence to the rule of priority, but is subversive of the purpose of nomenclature. Conformity with the code has therefore on the part of the botanists mentioned been governed by circumstances of practical expediency. They have kept in mind that nomenclature is only an aid to, not the aim of, the study of plants, and that a theoretically perfect nomenclature is inconsequent by the side of one which in practice admits of the ready recognition of the plants named; they have thought more of the identity of the plant and of its relationships than of the technical accuracy of the name under generally guiding principles, and have not therefore hesitated to cite older and obscure names as synonyms, and to ignore them if their use would replace others which had come to be generally and widely known. This principle of expediency and convenience, it has been said, is an unstable one, and to workers in fields of science in which it is not admitted may appear to be a mistake. But in the past of botany, in the hands of men really endeavouring to increase the general store of knowledge of plant-life, it has worked well. No doubt inconsistencies and mistakes may be found in the works of botanical writers who have acted upon it, traceable to a laxity which it introduces; but it has been a strong conservative element in nomenclature, whereas the application of the rule of strict priority has been most unsettling. For there are, unfortunately, men endowed with antiquarian zeal mated with sentiment which deems the naming of a species honour, and of a genus glory, who ferret through the pages of forgotten or unknown tracts or obscure journals, which perchance may contain a name, given by an author whose work has perhaps had no effect whatever upon the progress of the science, with which, under strict priority rules, they may supplant one custom has made part of popular language; or who rake out of correspondence (alas, that its preservation should serve such end) the history of private quarrels and jealousies of men whose names, as the roll of time has handed them down to us, carry only the attribute of scientific distinction, with the object of showing that one may have ignored the work of another, preceding it by a few days or weeks, and that consequently firmly established names must give place to those which strict priority demands. It is through such work, revelling in the overturning of authorities, which does not contribute to the progress of botany, and is essentially non-botanical, that many of the difficulties in nomenclature arise, and it merits the censure of all true botanists. Such work proves the wisdom of the botanists who have held aloof from binding agreement to strict priority rules, and against the load of synonymy and the confusion the strict priority rule would in these ways inflict upon plant-nomenclature, expediency and convenience are the protection to which appeal can be made. We are glad to note that in the "Index Kewensis" discretion has been exercised, and familiar and generally known names have not been sunk, although under the strict priority rule they should have been replaced by other and obscure ones.

That the procedure in the Index will meet with the universal acceptance of botanists may be hoped for; it cannot be expected immediately, when we have regard to the existing divergencies upon fundamental points. The laws of nomenclature formulated by the Paris Botanical Congress of 1867, made strict priority the basis of nomenclature, and were so generally adopted by systematic botanists out of England, that little was heard of the subject in subsequent years until a revolt of the younger American botanists against the practice of their former leaders—adherents to the line of expediency—brought it so prominently under notice a few years ago, that it has since been a staple of discussion in some botanical journals. Strict priority was the cry of the Americans, and some of them, with a zeal tinged with pedantry rather than bred of thought for the good of the science, endeavoured, in the application of the rule, to carry back to Virgil, Catullus, and other classical writers the scientific nomenclature of plants. But the event which most roused the attention of European botanists was the publication, in 1891, by Otto Kuntze, of his "Revisio generum plantarum"—a book remarkable no less for the industry and linguistic powers it exhibits than for its audacity and unconscious humour. Having assumed the *rôle* of a reformer of nomenclature, the author begins business by changing the names of some thousand genera and thirty thousand species, the new ones being only certified by the coincidently significant initials O. K.! As a curiosity of botanical literature the book will be historical; meanwhile its menace to systematic botany has had the effect of drawing from the Berlin school of systematists, which in recent years has shown so much activity, a statement of views which, after circulation, was submitted to the meeting of botanists at Genoa in 1892.

If the result of all the discussion and conference that has taken place has not been the establishment of a common agreement, they have at least served to bring out the points of divergence of view. We cannot, of course, discuss here the various issues upon which botanists are disagreed on this subject, but we may point out that the differences are mainly upon the starting point of nomenclature and the import of the specific name. The German school, which appears to carry with it a considerable bulk of continental opinion, prefers 1753 as the starting point for both genera and species to the date adopted in the Index, but makes an important declaration of adhesion to the principle of

expediency as qualifying the strict priority rule. The Americans have come round to fix 1753 as the starting point of nomenclature, but unfortunately tack on to the priority rule a rider compelling the use of the earliest specific apellation wherever the genus is changed—a proper enough rule if botanists would only follow it, but which, if carried out retrospectively, as they propose, would involve a changing of plant names appalling to contemplate.

We have said sufficient to show the importance of the "Index Kewensis," and to make clear that its issue at this time is most opportune. The professed desire of all systematic botanists—although there is a wide gulf often betwixt their profession and their practice—is the establishing of a stable nomenclature. To this end the "Index Kewensis" is the most important contribution that has appeared since the "Genera Plantarum" of Bentham and Hooker was completed, and it supplements that work. What effect it will have in bringing about a modification of the views now held by continental and American botanists time will show. In the various discussions and conferences through which it has been attempted to settle questions of nomenclature, the Kew botanists have not taken active part; they have done better, and in the "Genera Plantarum," and now in this "Index Kewensis," we have practical expression of their views, and systematic botanical literature is enriched with what may be fairly termed the most valuable and important additions of the century. The "Index Kewensis" provides a book of reference which every library must possess, and there need be little doubt its nomenclature will take firm hold in this country at least.

For the detail and workmanship in the book we have nothing but praise. They are of a kind we are in the habit of associating with the race which has given us "the sausage for food and the encyclopædia for knowledge," but the book shows there is no monopoly in this sort of work. It is a lasting tribute to the painstaking industry, skill, and knowledge of Mr. Daydon Jackson. The citation of the place of first publication of a species is a most valuable feature in the book, supplying at once a clue through which its history may be followed, and the mention of the native country, necessarily general and brief in most instances, is a further helpful feature. We could have wished for a more extensive citation of the garden names of plants; in every-day life these are constantly turning up, and of no names is the history more difficult to run down. In a work such as this, the preparation of which has taken so many years, and the separate items of which are so multitudinous, slips, omissions, and inconsistencies must occur; but the number of these, so far as use has enabled us to judge, is remarkably small. "Menda non commemorata lector benevolens ipse corriget," says Mr. Daydon Jackson, as a preface to a list of "addenda et corrigenda" in each fasciculus; let us hope readers will also send them to Mr. Daydon Jackson, who may incorporate them in succeeding fasciculi.

It only remains to add, regarding the style and printing of the book, that the best work of the Clarendon Press is displayed in it.

ASTRONOMY FOR THE PUBLIC.

In the High Heavens. By Sir Robert S. Ball, F.R.S. (London: Isbister and Co., 1893.)

IT is not too much to say that at the present time Sir Robert Ball is the fashionable interpreter of astronomical science. He retails to the general public, by voice and by pen, the facts accumulated by astronomers who love their science for her own sake, the practical observer and the eloquent expositor thus mutually benefiting one another.

The book before us contains a collection of heterogeneous articles, several of which have appeared in the *Contemporary* and *Fortnightly*, and all of which are written in the style that pertains to magazines. To the student of science this diffuse method of expounding facts is distasteful. As Ruskin has remarked, "A downright fact may be told in a plain way; and we want downright facts at present more than anything else." The chapter on "The 'Heat Wave' of 1892" furnishes an example of what can be done in the way of connecting facts between which there is apparently no relation. The chapter begins with a description of the temperature observations in different parts of the world in July and August, 1892; it then passes to the movements of the moon, transits of Venus, and meteor-showers, in illustration of the accuracy of astronomical predictions as against the prediction of weather. The work of Lord Kelvin and Prof. G. H. Darwin on tidal prediction is next considered, and the tide-predicting machine of the former is described. Fourier's theorem is discussed, and some of the causes affecting the heights of tides mentioned, the chapter finally concluding with an account of Prof. Hale's photographs of a luminous eruption on the sun in July, 1892. The different scraps of information in this *omnium gatherum* are joined together with an ingenuity that is only acquired after long practice; but in spite of this, the article gives one the impression that the author has spun out his subject in order to provide copy.

The star 1830 Groombridge is a "King Charles' Head" to Sir Robert Ball, the reason being its large proper motion. We doubt whether he has ever written a book in which the number of miles per second, per minute, per hour, per day, per annum, &c. through which 1830 Groombridge travels, is not enlarged upon; and in the volume under review this runaway star is twice inflicted upon the reader. So persistently, indeed, does 1830 Goombridge appear, that we begin to wonder whether it is hurrying through space at a great rate in order to afford subject-matter for popular lecturers and writers on astronomy.

Another subject that has often given Sir Robert Ball an opportunity of exercising his descriptive faculty is the correlation between solar and terrestrial phenomena. But in view of the facts recently brought out in these columns and elsewhere, he may find it necessary to modify or substantiate the statement that "great outbursts on the sun have been immediately followed, I might almost say accompanied, by remarkable magnetic disturbances on the earth."

For the sake of historical accuracy, it may be well to

point out that Prof. Rowland first made the striking remark that "were the whole earth heated to the temperature of the sun, its spectrum would probably resemble that of the sun very closely" (*Johns Hopkins University Circular*, No. 85, February, 1891). In referring to Prof. Rowland's work in August, 1891, at the British Association meeting of that year, Dr. Huggins made practically the same remark, and Sir Robert Ball (p. 169) quotes his words, and gives him the credit for the idea they contain.

Two of the chapters in the book refer to shooting-stars, meteors, and meteorites; and in them the author discusses the origin of meteorites and the relation between meteorites and comets. In his opinion, meteorites are masses of matter ejected from terrestrial volcanoes in a primeval condition of the earth; but we fancy that the analyses of most meteorites do not favour this origin. How, for instance, is the absence of quartz accounted for? But, as a matter of fact, Sir Robert Ball is almost the only astronomer who holds the volcanic view, and the same can be said with regard to his denial of the connection between comets and meteorites, and between meteorites and shooting-stars. The work of Schiaparelli and Newton, Tisserand, and Schulhoff, not to mention many others, considerably outweighs all that Sir Robert Ball has ever said upon the matter. The spectroscopic evidence upon the connection is dismissed in half a dozen lines, while page upon page is devoted to a description of what might happen to masses of matter projected from the moon or a minor planet. In fact, by discussing and judging these theories in a volume designed for the general reader, Sir Robert Ball has made a mistake. Though he has done some excellent mathematical work, astronomers are not at all ready to recognise him as a judge on matters of astronomical physics. His function is to expound and popularise discoveries in celestial science, and when he is exercising it he is at his best.

There are some good points about the book, and anyone desirous of obtaining information upon a few of the recent important discoveries in astronomy will profit by reading it. The illustrations are not so numerous as they ought to be, but what are included are mostly very good, though the illustration on p. 156, of the region of the Milky Way about β Cygni, should have been a positive instead of a negative, for in its present form it looks more like a pathological section than anything else.

It would be an advantage if, in a future edition, the author would give the name of the observer of the solar eruptions figured on pp. 271, 273, 338, and 339. We fancy that Father Fenyi was the original draughtsman of the prominence forms there illustrated, but cannot find his name mentioned in the text relating to them.

R. A. GREGORY.

OUR BOOK SHELF.

Practical Agricultural Chemistry for Elementary Students. By J. Bernard Coleman, A.R.C.Sc., F.I.C., and Frank T. Addyman, B.Sc., F.I.C. (London: Longmans, Green, and Co., 1893.)

"THE course of instruction described in this book has been in use for some years at University College, Nottingham." After a few instructions as to the use of apparatus, there follows a short course of experiments on oxygen, air, carbonic acid, water, and hydrogen. The third section treats experimentally of soils, manures, feeding materials, and dairy produce, and gives a number of simple experiments that serve to show many of the most important properties of these substances. For example, the differences between the sulphur present in gas-lime and in gypsum respectively, and the various conditions in which phosphoric acid occurs in superphosphates, bone phosphates, reverted phosphate, and slag phosphates are made the subjects of experiment, Tests are given for the various constituents of manures. Oilcakes, grass and hay, roots, flour, milk, butter and cheese, are dealt with in a similar manner. The fourth section of the volume gives a few reactions of a select number of metals (viz. seven) and acids, with a few other matters, and tables for the qualitative analysis of substances containing them. We would remark in reference to this, that to allow students to fuse insoluble substances in porcelain crucibles, in order to test for silica, is, to say the least of it, undesirable.

Regarding the volume as a whole, it forms an excellent addition to an ordinary student's course of agriculture, whether this is, as is too often the case, only a matter of listening to a few lectures, or whether practical agriculture forms an essential part of it. Perhaps it is hardly possible for a teacher to take much account of the danger that is proverbially inseparable from a little knowledge; but in cases where this is particularly liable to manifest itself, it may be his duty to do what he can to obviate the evil. Speaking from experience, we fear there are students who, after having worked through these seventy-one pages, would not hesitate to state that they had studied inorganic and organic practical chemistry at whatever college they might have done the work. In this way it is at least possible for grave discredit to be brought undeservedly upon the usual course in chemistry at such a college; for there are many people with no technical knowledge of these matters, who attach considerable value to the mere fact that a specific routine of study has been gone through at a well-known educational establishment. It appears, therefore, to be highly desirable to do whatever may be possible to prevent such a chemical course as that in this volume from being in any way confused with even the most elementary course that is arranged to impart a knowledge of chemistry itself. A similar danger doubtless exists in many other cases, but it may probably be said with truth, that there is in none other likely to be so great a temptation to misrepresent facts by an incomplete statement of the truth. C. J.

Bionomie des Meeres. Von Johannes Walther. Erster Theil einer Einleitung in die Geologie als historische Wissenschaft. (Jena: Gustav Fischer, 1893.)

PROF. WALTHER has set before himself an ambitious programme, which, if carried out, should result in a geological treatise of great interest; we fear also of portentous length. The first instalment is a modest little book of 200 pages, with a preface summarising the travels and researches which the author made for ten years with a view to fit himself for the task, and a separately paged introduction defining the scope of the contemplated work, and enunciating the ontological method in geology. Bionomy is the study of the life-habits of organisms in relation to their environment, and it is obvious that the bionomy of the ocean at the present time must be the clue to all deductions from the character of marine fossils regarding the physical conditions in which they were produced.

Prof. Walther is extremely systematic, and in twenty numbered sections he summarises a vast amount of recent work on the relation between marine organisms and physical conditions. His numerous references to original memoirs might be profitably increased by the inclusion of more British, French, and American work, and espe-

cially by some indication of such piles of raw material for discussion as have been accumulated by the Fishery Departments of many governments. A compilation of this sort depends for its value on its completeness, as the reason for adopting one theory or classification rather than another must be the outcome of an attempt to weigh evidence. After a brief discussion of the conditions of life, there follow sections on the life-districts of the ocean, Hæckel's classification of marine organisms, a concise discussion of the influence of light, temperature, salinity, tides, waves, and currents on marine life, and a short statement of the flora and fauna of the littoral, shallow water, estuarine, open sea, deep sea, and oceanic archipelago divisions, concluding with a few pages on the geological changes of ocean basins.

It would be premature to express an opinion of Prof. Walther's contemplated work. The sketch he gives of its plan stimulates interest and curiosity, and we can heartily congratulate him on the orderly way in which he has collected and laid down the building-material, while we wish him success in his labours.

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.*]

Correlation of Solar and Magnetic Phenomena.

THE opinion of Mr. Whipple, quoted at p. 2 of NATURE for November 2, to the effect that the solar outburst observed by Messrs. Carrington and Hodgson on September 1, 1859, was not the cause of the coincident magnetic perturbations, corresponds to my own conclusion in regard to the matter based upon evidence of an altogether different character. There was a recurrence of strong magnetic perturbations and auroras twenty-seven days later than the great magnetic storms of August 28 and September 1, 1859, thus following the general rule which is found to apply in such cases, there being a well-marked periodicity of such outbreaks at this precise interval corresponding to the time of a synodic rotation of the sun. Such recurrence manifestly could not exist if outbreaks upon the sun were able to produce terrestrial magnetic effects indifferently in all locations. In order that there may be recurrence at the synodic period the magnetic effects must proceed from the sun at some particular angle exclusively, and fortuitous outbursts elsewhere, no matter how violent, must fail to have any perceptible effect. In the estimation of the writer there is no point more important in connection with solar physics than the determination of this period and this angle with the greatest accuracy possible. M. A. VEEDER,

Lyons, N.Y., December 26, 1893.

MY letter in NATURE (vol. xlix. page 30), amongst other interesting communications, has brought one from Mr. Lawrance (vol. xlix. page 101) and the accompanying letter from Dr. Veeder. Mr. Lawrance's graphic account well describes the circumstances attending the manifestation of 1882 (November 17). The magnetic disturbance which broke out at 10 a.m. on that day set us all on the look-out for aurora in the evening. Neither were we disappointed; the display was remarkable. But the question in this case, as with the Carrington-Hodgson and Young instances, is still whether the solar and magnetic phenomena were directly related or simply coincident. This cannot be said to be determined, and nothing less than proof, in so important a matter, will serve. Better to advance surely if slowly towards truth, rather than accept too hastily evidence that is incomplete. We must remember that on the occasion of the solar disturbance seen by Trouvelot, the magnets were especially quiet, not only at the time but also before and after. But any explanation of these phenomena must include all cases. The position of things, as stated in my first letter, referred to above, still I consider holds, qualified only by the circumstance that instead of one presumed case of direct relation, three are now adduced, with a fourth case (the Trouvelot observation), which unquestionably was not accompanied by magnetic disturbance. If we further consider that, since the year 1859, when attention became distinctly drawn to this question, there has occurred magnetic movement, equal to and in very many cases far exceeding that accompanying the Carrington-Hodgson observation, on some 400 different days, we see on how slight a foundation the presumption for direct relation, that is of a nature more or less instantaneous in action, exists, although the general relation between the two classes of phenomena remains undoubted.

Dr. Veeder, from his own point of view, supports the contention that the 1859 solar outburst cannot be taken as causing the accompanying moderate magnetic movement; indeed there was far greater movement some three days previously, and again early on the morning of the following day; but in regard to his affirmation that there exists a well-marked periodicity in magnetic outbursts corresponding to the period of the sun's rotation, whilst this in a limited sense may be in some degree true, I cannot say that my personal acquaintance with magnetic records during very many years enables me at present to accept such conclusion as a general one, or indeed what as a consequence follows, that anything really depends on the position in rotation which the sun occupies relatively to the earth.

The whole subject is, however, exceedingly interesting, and various considerations arise. One bearing on the present question may be mentioned. Great terrestrial magnetic disturbances are evidently in character cosmical, produced, it would seem, or stimulated, by some external cause. For it has been shown (Proc. Roy. Soc. vol. lii. p. 191) that, on occasions of unusually sudden magnetic disturbance, the commencement of disturbance, at places so widely separated on the earth's surface as Greenwich, Pawlowsk, and Bombay, is simultaneous within a much smaller limit of time than had before been supposed. Such sudden simultaneous action would thus appear to indicate an impulse, solar or otherwise, from without, but whether one distinctly solar, or in what other way produced, is a question yet to be determined. WILLIAM ELLIS.

Greenwich, January 6.

The Mendip Earthquake of December 30–31, 1893.

I SUBMIT the following notes for the use of any of your readers who may be collecting information on the subject:—

So far as I can judge, from statements obtained directly from inhabitants of the locality, and from the experiences of various persons, recorded in the *Shepton Mallet Journal* of January 5, the movements in this earthquake occurred chiefly along the south flank of the Mendip Hills between Shepton Mallet on the east-south-east, and Draycott (near Cheddar) on the west-north-west. The shock extended as far southwards as Evercreech and West Pennard; it reached as high up as Priddy, which is near the axis of the hills, and was also noticed at Chewton, several miles distant on the northern flank.

The force of the shocks appears to have been very irregularly distributed, in some houses the movements being quite alarming, while in others not far distant they were trifling though unmistakable. Some persons failed to hear the sound, which was very evident to others. Persons out of doors heard the sound most distinctly, even when they felt no shock.

A lady at Shepton Mallet, who had previously experienced an earthquake in New Zealand, recognised at once what was occurring, but was not in any way alarmed. She says that her bed began suddenly to shake or rock, and as suddenly ceased. She was also conscious of a movement of the whole house, and in the sharper shock heard the furniture rattle; but she did not observe any rumbling. Another lady in the same house noticed particularly the "funny unusual sort of noise." Again, in the same house a man describes the movement as resembling a wave moving from east to west. A school master and mistress got up under the impression that the water-heating apparatus had burst. At West Compton a lady in a farmhouse thought from the sound and movement "that some one was about the house, or that a barrel of cider had burst." At Westbury-below-Wells the shock was sharp enough to cause alarm.

The policeman on duty at Shepton Mallet very naturally referred the sound to the direction of the Midland Railway, which runs high on the hills in such a way that the rumble of its trains is heard at a great distance. It is well known that we have but little certainty in localising sounds, especially if of indefinite character, and that we usually refer them to positions whence we expect them.

The area in which the earth-movements seem to have been

most felt, corresponds with a series of outlying masses of carboniferous limestone, which are separate from the main mass of carboniferous limestone of the Mendip anticlinal. Whether these are parts of another anticlinal, or owe their position to faulting, I do not know. Westward of Wells these outliers form little knolls, as at Draycott and Westbury. Further east, in the area between Wells, Shepton Mallet, and West Compton, they form a group of prominent hills, whose valleys are occupied by later formations. If such outliers exist east of Shepton Mallet, they are deeply hidden by the oolitic strata.

Evercreech and West Pennard lie off this carboniferous limestone, but it extends beneath the valley in which these villages lie. Priddy is on the main anticlinal of the Priddy Mendip hills, and Chewton is separated from all the foregoing by the exposure of Old Red Sandstone. It would be interesting to know how far the Old Red Sandstone shared the movements; but information is likely to be scanty, as the sandstone forms a bleak and sparsely inhabited region. F. J. ALLEN.

Mason College, Birmingham, January 6.

Quaternionic Innovations.

THAT Prof. Tait should not be able to do justice to those who prefer to treat vectors as vectors, and quaternions as quaternions, instead of commingling their diverse natures, with the result, in the latter case, of confusion of physical ideas (and geometrical also, for of course geometry is itself ultimately a physical science, having an experiential foundation), is naturally to be expected. He does not know their ways, either of thinking or of working, as is abundantly evident in all that he has written adversely to Prof. Willard Gibbs and others. It is, however, a little strange, in view of Prof. Tait's often expressed conservatism regarding Quaternionics, that he should tolerate *any* innovations therein, such as Mr. MacAulay has introduced. The latter may perhaps take this as a compliment to his analytical powers, which compel the former's admiration, and toleration of his departures from quaternionic usage. For myself, I welcome any quaternionic innovations that may (ultimately) tend in the direction of the standpoint assumed by Prof. Gibbs and others, and foresaw some two years since (when a very bulky manuscript came to me for my opinion) that there would be some quaternionic upstirring.

Prof. Gibbs has already pointed out how the development of Quaternionics has involved first the elimination of the imaginary, and next the gradual elimination of the quaternion! Now there is a capital illustration of this innate tendency in Prof. Tait's review (NATURE, December 28, 1893), where, on p. 194, he explains by an example the meaning of a startling innovation of Mr. MacAulay's. Put it, however, in vectorial form, and let us see what it comes to then. Take the case of a stress and the force to correspond (which is a little easier than Prof. Tait's example, though not essentially different). Let ϕ be a stress operator (pure, for simplicity), so that $\phi\mathbf{N}$, or $\mathbf{N}\phi$, is the stress per unit area on the $\mathbf{N}$ plane, $\mathbf{N}$ being any unit vector. Now we know, by consideration of the stresses acting upon the faces of a unit cube, that the $\mathbf{N}$ component of the force $\mathbf{F}$ per unit volume is the divergence of the stress vector for the $\mathbf{N}$ planes. That is,

$$\mathbf{FN}=\nabla\phi\mathbf{N}, \qquad (1)$$

for any direction of $\mathbf{N}$. I employ my usual notation for the benefit of readers (now becoming numerous) who, though they cannot follow the obscure quaternionic processes, can understand the plainer ones of pure vector algebra. Now, may we remove the vector $\mathbf{N}$ (which is any one of an infinite number of vectors) and write

$$\mathbf{F}=\nabla\phi \text{ or } =\phi\nabla \qquad (2)$$

simply, as the complete expression for the force? Certainly we may. For, in full, we have

$$\nabla=\mathbf{i}\nabla_1+\mathbf{j}\nabla_2+\mathbf{k}\nabla_3, \qquad (3)$$

$$\phi=\phi_1.\mathbf{i}+\phi_2.\mathbf{j}+\phi_3.\mathbf{k} \text{ or } =\mathbf{i}.\phi_1+\mathbf{j}.\phi_2+\mathbf{k}.\phi_3, \qquad (4)$$

where ∇_1, &c. are the scalar components of the vector ∇ (not a quaternion, of course) and ϕ_1, &c. are the vector stresses on the planes of $\mathbf{i}$, &c., so that $\phi_1=\phi\mathbf{i}$, &c. Direct multiplication gives at once

$$\nabla\phi=\nabla_1\phi_1+\nabla_2\phi_2+\nabla_3\phi_3, \qquad (5)$$

which is $\mathbf{F}$. We may also write it $\phi\nabla$, because ϕ is pure.

On the other hand, when ϕ is rotational, let its conjugate be ϕ', then instead of (1) we have

$$\mathbf{FN}=\nabla\phi'\mathbf{N}, \qquad (6)$$

and therefore

$$\mathbf{F}=\nabla\phi'=\phi\nabla. \qquad (7)$$

Here if ϕ is given by the first expansion in (4), ϕ' is given by the second.

Now there are several things that deserve to be pointed out about the above, which should be compared with Prof. Tait on p. 194. First, that the result $\mathbf{F}=\phi\nabla$, irrespective of pureness, or $\mathbf{F}=\nabla\phi$ also when the stress is pure, when got quaternionically seems to be a great novelty to Prof. Tait, and to give him a "severe wrench," involving a "dislocation" and a "startling innovation." Perhaps, however, it is only Mr. Macaulay's peculiar way of arriving at the result, that Prof. Tait is alluding to. Moreover, secondly, in the vector algebra of Willard Gibbs and others the use of equation (2) or of (7) to express the force complete, by removal of the intermediate vector $\mathbf{N}$, is neither new, nor does it involve any straining of the intellect, for it is actually a part of the system itself, done naturally and in harmony with Cartesian mathematics. See Gibbs's "Elements of Vector Analysis" (1881–4) for the direct product of ∇ and ϕ. (Also for the skew product, a more advanced idea; it, too, is a physically useful result.) Thirdly, note how very differently the same thing presents itself to Prof. Tait according as it is clothed in his favourite quaternionic garb or in vectorial vestments. In the latter case it is either unnoticed or is contemptible; in the former, it may be a novel and valuable improvement.

I do not think that Prof. Tait does justice to Mr. MacAulay in making so much of a trifle such as passes unnoticed or unappreciated in the previous work of others. There is, I know, much more in Mr. MacAulay's mathematics than Prof. Tait has yet fathomed. For my own part, I like to translate it into vectors, not merely because it is then in a form I am used to, and is plainer, but also because the true inwardness of these processes involving linear operators is properly exhibited by the dyadical way of viewing them in conjunction with vectors, without the forced and unnatural amalgamation with quaternions, and the attendant obscurities. This seems to me to be particularly true in physical applications. I should not be writing this note were it not for the misconceptions that Prof. Tait indulges in about what he does not know, viz. vector algebra apart from quaternions. At the same time, to avoid possible misunderstanding, I disclaim any hostility to Mr. MacAulay's quaternionic innovations, although I must agree with Prof. Tait as to the "singular uncouthness" of some of his expressions in their present form. I hope he may be able to see his way to do his work vectorially. It will be more amenable to innovations, I think, without mental wrenches. At any rate he is a reformer, and not afraid to innovate when he thinks fit.

OLIVER HEAVISIDE.

Paignton, Devon, December 30, 1893.

The Second Law of Thermodynamics.

I APOLOGISE to Mr. Bryan for unintentionally reading into the Report, Article 17, what he did not intend to be there. I understand now that according to his view conservative systems are not alone to be included in the Clausian proof.

My point, however, is (or was) that they ought to be excluded, at all events when there is only one controllable coordinate v, because (1) in conservative systems the virial equation gives a relation between T and v, so that only one of them is independent. That, I submit, is true in fact. And (2) the second law, I said, requires two independent variables. That, however, is a question of definition, and if Mr. Bryan were to take the equation

$$\int\frac{\partial Q}{T}=0$$

for a complete cycle, whatever be the nature of the system, as a definition of the second law, I see no valid objection to that definition.

I admit, and did admit, that for a conservative system, moving in a complete cycle,

$$\int\frac{\partial Q}{T}=0,$$

and therefore I admit that if Mr. Bryan attaches his wheel and windlass to my pistin of constant mass, we should get

$$\int \frac{\partial Q}{T} = 0$$

for each complete turn of the wheel. Whether that equation can be correctly said to express the second law, where there is only one independent variable, is a question of definition of the second law.

I said, also, that if we are at liberty to vary the mass of the pistin, we have two independent variables, but no longer a conservative system. Mr. Bryan, with greater generality, points out that the same effect would be produced by altering the gravitation-potential.

The objections to Clausius's proof generally cannot be more forcibly stated than they are in the Report. What is required is a definition of the time "*i*." The absence of that definition is to my mind not only an objection, but a quite fatal objection. If, as I proposed, we make

$$i = \frac{v^2}{T^2},$$

that answers the purpose for the very limited class of cases in which

$$\partial \bar{\chi} = \frac{\overline{d\chi}}{dv} \partial v.$$

A treatment of the subject in generalised coordinates is as follows:—Let $y_1 \ldots y_n$ be the unconstrainable, $q_1 \ldots q_r$ the controllable coordinates, concerning which latter I assume, as does Boltzmann, that $\dot{q}$ or $\frac{dq}{dt}$, and also $\frac{d^2q}{dt^2}$ are to be neglected. Let χ be the potential, τ the kinetic energy, T the mean value of τ. Then we have generally

$$\frac{\partial Q}{T} = \partial \log T + \frac{1}{T}\left\{\partial \chi + \Sigma\left(\frac{\overline{dt}}{dq} - \frac{\overline{d\chi}}{dq}\right) dq\right\}.$$

In some cases the term $\frac{dT}{dq}$ does not appear, and therefore in this class of cases

$$\frac{\partial Q}{T} = \partial \log T + \frac{1}{T}\left(\partial \bar{\chi} - \Sigma \frac{\overline{d\chi}}{dq} dq\right).$$

Now let $f dy_1 \ldots dy_n$ be the chance that in the stationary motion with the q's constant, the coordinates shall lie between the limits y_1 and $y_1 + dy_1$, &c., so that

$$\bar{\chi} = \int\int \ldots \chi f dy_1 \ldots dy_n$$

and

$$\frac{\overline{d\chi}}{dq} = \int\int \ldots \frac{d\chi}{dq} f dy_1 \ldots dy_n.$$

This makes

$$\partial \bar{\chi} - \Sigma \frac{\overline{d\chi}}{dq} \partial q = \int\int \ldots \chi \partial f dy_1 \ldots dy_n,$$

and

$$\frac{\partial Q}{T} = \partial \log T + \int\int \ldots \frac{\chi}{T} \partial f dy_1 \ldots dy_n.$$

In order that $\frac{\partial Q}{T}$ may be a complete differential, we must make $f = \phi\left(\frac{\chi}{T}\right)$, where ϕ is an arbitrary function. That is the general solution.

Now it will be found that this general solution agrees exactly with that given by Mr. Nichols. For his condition is

$$\frac{1}{T}\left(\frac{d}{dv}\bar{\chi} - \frac{\overline{d\chi}}{dv}\right) = -\frac{d}{dT}\frac{\overline{d\chi}}{dv}.$$

Now the use of these averages necessarily implies the existence of a function f, such that

$$\bar{\chi} = \int f \chi d\sigma, \quad \frac{\overline{d\chi}}{dv} = \int f \frac{d\chi}{dv} d\sigma,$$

the integrations being with proper coordinates, and therefore

$$\frac{d}{dv}\bar{\chi} - \frac{\overline{d\chi}}{dv} = \int \chi \frac{df}{dv} d\sigma.$$

Mr. Nichols' condition may therefore, without loss of its generality, be put in the form

$$\int \frac{\chi}{T} \frac{af}{dv} d\sigma = -\int \frac{d\chi}{dv} \frac{df}{dT} d\sigma.$$

The general solution of this is

$$f = \phi\left(\frac{\chi}{T}\right),$$

as before

That equation,

$$f = \phi\left(\frac{\chi}{T}\right),$$

seems to me to define the limits of the second law for all cases in which the term $\frac{dT}{dq}$ does not appear in Lagrange's equations.

I hope if Mr. Bryan comes to discuss the virial proof, he will give his opinion on this point.

I think that the term $\frac{1}{T}\frac{d\tau}{dq}$, when it exists, can be made to lead to a somewhat similar condition. If, namely, F be the chance of a given combination of the velocities,

$$\frac{1}{T}\frac{\overline{d\tau}}{dq} = \int \frac{F}{T}\frac{d\tau}{dq} d\sigma = -\int \frac{\tau}{T}\frac{dF}{dq} d\sigma$$

$$= -\int \frac{\tau}{T} \partial F d\sigma + \partial \log T,$$

whence F must be a function of $\frac{\tau}{T}$.

I have to thank Mr. Bryan for reminding me of Mr. Nichols' paper, which I had forgotten, though I had some discussion with its author at the time.

S. H. BURBURY.

The Fauna of the Victoria Regia Tank in the Botanical Gardens.

PROF. LANKESTER'S account of the "Freshwater Medusa," in NATURE, December 7, 1893, shows how with very little trouble the interests of zoologists may be served by those who have the charge of botanical gardens like that in the Regent's Park. All that is necessary is to refrain from periodically cleaning out the tanks in which tropical water plants are grown. When these latter are imported from abroad they often carry with them various aquatic animals of novelty or interest like the medusa mentioned. This particular tank has recently produced quite a number of remarkable animals. Mr. Bousfield, some years since, found certain new or little known species of *Dero* therein, and more recently Prof. A. G. Bourne met with a new form of the Naid genus *Pristina* in the same tank. I have been able, thanks to the courtesy of Mr. Sowerby, to examine water and decaying weed therefrom on more than one occasion, and I discovered a series of rare or novel species of *Oligochæta*. The most remarkable form was one which I described a year or two since as a new genus *Branchiura;* this worm, with the general characters of a *Tubifex*, possesses a row of dorsal and ventral branchial processes, besides showing other points of interest. In the same sample of water were large quantities of a Naid, called by its original describer, Prof. Bourne, who met with it in the town of Calcutta, *Chætobranchus semperi*. This worm has also a series of branchiæ, but they are lateral in position, and enclose the long dorsal setæ of the Annelid, thus suggesting the parapodia of the marine Chætopods. I have also found the rare species *Æolosoma niveum* in the same locality, and a freshwater Nemertine (♀ *Tetrasteruma aquarum dulcium*), besides a number of Oligochæta which I did not at the time identify.

FRANK E. BEDDARD.

Rudimentary (Vestigial) Organs.

PROF. HARTOG'S letter in your issue of the 28th ult. is interesting as an illustration of the extreme danger of regarding an organ as vestigial and functionless merely because our superficial investigations have not revealed to us its use.

If Prof. Hartog had examined the distal knob of the modern eyeglass, even by the old-fashioned macroscopic methods, he would have seen that there passes through a screw, whose function is to hold the two sides of the oval frame together, and thus retain the lens in place.

The knob is also useful as a convenient point to lay hold of

in drawing the two lenses apart. We may, I think, prophesy that these two functions will secure the organ against disappearance. W. E. H.

ALLOW me, as a wearer of the modern style double eye-glass, to point out to Prof. Marcus Hartog that the knob on the distal frame owes its survival to its utility. Though no longer of service as a lock on a folder, it yet serves to lay hold of when drawing the frames asunder to put on the nose. It is one of the drawbacks of the modern eye-glass that it takes both hands to fix or remove. C. MOSTYN.

National Liberal Club, Whitehall Place, S.W., January 4.

FRESH LIGHT ON THE AINU.[1]

MR. A. H. SAVAGE LANDOR, grandson of the poet, and himself a talented artist, recently made a remarkable journey round the island of Yezo, and up

many of its large rivers, repeating Captain Blakiston's route in 1869 so far as regards the north-east and west coasts, but supplementing that traveller's journey along the whole east coast and in the interior. He travelled alone, with practically no equipment except for painting; and during five months he lived almost exclusively with the Ainu, even sharing their food. He visited in this way nearly every native village in Yezo, and estimates the total number of pure-bred Ainu now on the island at about 8000, while the Japanese estimate of the whole Ainu population, including half-breeds, is from 15,000 to 17,000. Mr. Landor gives a lively and straightforward account of his journey, illustrated by numerous portraits, pieces of landscape, and drawings of houses and implements, which is replete with incidental information as to the ways of the primitive people and the minor adventures of the road. No European has previously covered so much ground in Yezo, and we are surprised at the modest size of the volume in which so many fresh observations are recorded for the first time. The geographical results of the journey were communicated, shortly after his return, to the Royal Geographical Society, and published, with a map of the island (reproduced, with some additions, in this volume), in the last part of the Society's "Supplementary Papers." We are not aware that the anthropological data have yet been submitted to specialists, but we feel confident that they will assist notably in forwarding our knowledge of the difficult problems of Ainu ethnology. The author as an artist has a keen and discriminating eye for form and colour, so that his observations carry much more weight than the chance remarks of most non-scientific travellers. It seems a pity that some of the portraits are not reproduced in colour, and we trust that an effort will be made to secure for anthropological collections some of the original pictures, which we understand are still in Mr. Landor's possession.

In the course of the narrative a chapter is inserted on the Koro-pok-kuru, or early pit-dwellers, the supposed aborigines of Yezo; ten chapters at the end are devoted to Ainu architecture, art, and graves, Ainu heads and their physiognomy, movements and attitudes, clothes, ornaments and tattooing, music, poetry and dancing, heredity, crosses, psychological observations, physiological observations, pulse-beat and respiration, odour of the Ainu, the five senses, superstitions, morals, laws and punishments, marital relations and the causes that limit population.

These and an appendix giving measurements of the Ainu body constitute a definite addition to science, which loses but little of its value through being expressed in popular language. Indeed, it is a matter of some importance that such facts should be disseminated by a book which, altogether apart from its intrinsic value, will be widely read on account of its fascinating human interest.

The illustrations which we reproduce are extremely characteristic portraits, showing admirably the hairy character of the men, and the well-known fashion of tattooing a moustache on the women.

The average measurements of ten pure Ainu (five men and five women) of Frishikobets, on the upper Tokachi river, were as follows:—Height, 62½ inches for men, 58⅜ inches for women; length from tip to tip of fingers with arms outstretched, 65⅜ inches for men, 61¼ inches for women; chest measurement, 37 1/10 for men, 34⅕ for women. The pure Ainu physiognomy is described as follows:—"When seen full-face the forehead is narrow and sharply sloped backward, the cheek-bones are prominent, and the nose is hooked, slightly flattened, and broad, with wide, strong nostrils. The mouth is generally

[1] "Alone with the Hairy Ainu; or, 3800 Miles on a Pack Saddle in Yezo, and a Cruise to the Kurile Islands." By A. H. Savage Landor. (London: John Murray, 1893.)

large, with thick, firm lips, and the underlip well developed. The space from the nose to the mouth is extremely long, while the chin, which is rather round, is comparatively short and not very prominent. Thus the face has the shape of a short oval. The profile is concave, and the mouth and eyebrows are prominent . . . . In the supraorbital region the central boss is extremely well marked ; also the brow ridges, which, however, are slightly less conspicuous than the central boss. The ears are usually large, flat, and simply-developed." Mr. Landor shows, by a series of detailed contrasts, that the pure Ainu has no similarity whatever to the Mongolian type. The colour of the skin he found to be light reddish brown. The eye is particularly contrasted to the Mongolian eye, having a similar form and setting to that of North Europeans, while the iris is light brown or dark grey—rarely black or dark brown, except in the case of half-breeds. The eyes are very expressive, and show the emotions in an interesting way. In adults the hair is black, wavy, and inclined to form large curls ; children have lighter hair, and in the north-east of Yezo several men were seen with reddish hair and beard. Mr. Landor never saw the

pure Ainu laugh, though on one occasion he induced a man to "roar" with surprise and delight. The various emotions are expressed by slight changes of posture or gesture, but the Ainu do not care to show their feelings ; they have no sense of shame, and even fear appears hardly to be known.

The women do most of the hard work, but the men when hunting can walk forty miles a day without fatigue, although they usually prefer to ride, ponies being plentiful and of a good breed. In moving a load or heavy object the Ainu never push, but always pull towards them. They appear to use the feet and toes very freely to help their hands and fingers, and they readily employ their teeth, preferring to pull with the teeth than the hand when an unusually heavy haul is necessary. The whole appearance struck Mr. Landor as exactly like the reconstructions of the primitive man of northern Europe, and many of their movements recalled those of the anthropoid apes.

In sexual matters the Ainu appear to have no definite rules, but a form of endogamy is common, which scarcely differs from promiscuity. The people are extremely filthy, both in their persons and in their huts, the prevalence of insect parasites being remarkable. They seem to have an acute sense of smell, distinguishing between the odour of an Englishman and a Japanese, but oblivious to their own very marked perfume—an intensified form of the "peculiar odour of an uncleaned monkey's cage." The sense of touch is singularly defective, and even when the extremes are painful, they cannot distinguish the sensation of heat from that of cold. Their hearing is very acute.

Mr. Landor is severe on those writers whose imperfect acquaintance with the Japanese half-castes on the southern coast has led them to theorise on Ainu religion. He acknowledges only "a rudimentary kind of totemism" in connection with the bear festivals, and "a certain amount of fear and respect for anything that supports their life or can destroy it."

In every respect the new observations now published make the Ainu appear to be the most primitive of primitive races in the northern hemisphere. The author brings forward reasons which led him to believe that the Ainu, coming from the north of Asia, and possibly of the same stock as the North Europeans, conquered and dispossessed the Koro-pok-kuru who had come to Yezo from the Aleutian Islands and were akin to the Eskimo.

H. R. M.

THE PURIFICATION OF SEWAGE BY BACTERIA.[1]

THE diffusion of bacteriological knowledge amongst the general public is already beginning to affect the patent list, and numerous inventions which the world is at present asked to take advantage of claim to have some special efficacy in regard to micro-organisms. The pamphlet before us is intended to introduce to public notice one of these bacteriological inventions in a field which has already exercised the ingenuity of many inventors—both professional and amateur—viz., the purification of sewage. In this case the invention is called the "cultivation filter-bed," and the inventor is Mr. Scott Moncrieff, whilst the investigation of its efficiency has been made by Dr. A. C. Houston. The new process of treatment consists essentially in passing the sewage upwards through a filtering medium 14 inches in depth, and composed of successive layers of flint, coke, and gravel. To quote the words of the report, "the *rationale* of this system of sewage disposal seems to depend on the following well-recognised truths :—

"1. That bacteria under favourable conditions are capable of indefinite multiplication.

"2. That bacteria exist in sewage which are capable of peptonising solid organic matter, or, in other words, of preparing it, by a process comparable to that of digestion, for its final disintegration.

"3. That in nature the purification of the refuse of the organic world is effected by the life-history of these or similar micro-organisms."

Having thus learnt what the nature of the method of treatment is—viz. upward filtration without aëration, or, in other words, putrefaction, we turn in the next instance for information as to the effect of this treatment. The report contains a number of analytical tables, but not one of the analyses shows us the composition of the crude sewage, and consequently the numerous analyses of the effluent furnish no data whatsoever as to the purification effected. Turning to the analyses of the effluent, however, we are not surprised to learn that it has generally an unpleasant odour, whilst the albuminoid ammonia in an average sample was 1·1 part per 100,000 ; but why this should be regarded as "very small," we are

[1] "Report upon the Scott Moncrieff System for the Bacteriological Purification of Sewage." By Alex. C. Houston, M.B., D.Sc. Edin. (London : Waterlow Bros., 1893.)

at a loss to discover. Nor was even the inventor apparently satisfied, for we are told in the report that "in order to still further improve the quality of the effluent by longitudinal filtration, by oxidation, and by the action of micro-organisms, Mr. Scott Moncrieff devised what he has termed nitrifying channels. These in their simplest form consist of half-channel pipes joined together with cement and filled with coke." These channels were originally 30 feet in length, but subsequently they were increased to 80 feet. As regards the efficiency, or rather inefficiency of these channels, we are able to form an opinion from analyses given on pp. 19 and 20 of the report; from these it appears that the free ammonia *before* was 3·2 parts per 100,000, and *after* passing through the 80 feet channel 3·6 parts, whilst the albuminoid ammonia was ·8 part *before*, and ·64 part *after*, respectively, whilst in no case was more than a very small proportion of nitrate discovered in this effluent, showing that these channels are "nitrifying" in name only.

If we now inquire into the machinery involved in producing these results, we find that for a household of ten to twelve persons, the filter-bed was 10 feet long by 2½ feet wide, or 25 square feet in area, whilst the so-called nitrifying channel superadded to this was 80 feet in length (the diameter of these channels is not given). For a population of 1000 persons, therefore, a filter-bed, upwards of 2000 feet square, and a nitrifying channel, between 6000 and 7000 feet in length, would be necessary.

It is difficult to discover what claim to novelty Mr. Moncrieff's system possesses; the upward filtration of sewage was practised years ago, and has been generally abandoned on account of the far superior results obtained by downward intermittent filtration. As regards the nitrifying channels, these are simply downward filters of a very clumsy and expensive form, the inefficiency of which is attested by the analyses published in the report. One novelty indeed there is in Mr. Moncrieff's filters, to which they doubtless owe their "up-to-date" title of "cultivation filter-beds," for we are informed that when a new filter-bed is started it is "inoculated" with the liquid contents of an old one! As already pointed out, in the absence of any analyses of the raw sewage, the report gives us no information as to the work really done by the "cultivation filter-bed," but the effluent coming from it certainly contrasts very unfavourably with good effluents obtained either by filtration, irrigation, or chemical precipitation; as regards the work done by the "nitrifying channels," the analyses demonstrate this to be simply deplorable.

In conclusion, we would remark that the chemical analyses might advantageously have been made more complete, so as to render the figures comparable with those given in the best investigations on the purification of sewage; and we would point out that an analysis is not rendered more exhaustive either by expressing each determination in parts per 100,000 as well as in grains per gallon, or by drawing out the results in elaborate but meaningless curves of divers colours.

ARTHUR MILNES MARSHALL.

A GLOOM has been cast over the opening year by the news of what can only be described as a national calamity. Like his friend, Prof. F. M. Balfour, Milnes Marshall has been cut off in the midst of a life of scientific usefulness by an accident among the mountains which he loved. On the last day of 1893 Prof. Marshall, with several companions, started from the hotel at Wasdale Head for a day's climbing among the precipices of Scawfell. All the dangers and difficulties had been passed, and the party were looking for suitable views to photograph. Dr. Marshall had mounted a few feet higher than the others, and called out, "Here is the best place for the camera," when almost immediately a large stone was seen to fall, followed by his apparently lifeless body. The precise details of the mishap will never be known—whether he stepped or sat down upon a rock loosened by the frost, or whether, as is thought by some well qualified to judge to be more likely, a stone fell upon him from above—must remain a matter for conjecture. The melancholy fact is sufficient that a young and brilliant student of nature passed in an instant from the full enjoyment of health and strength to the "cold obstruction" of death.

Arthur Milnes Marshall was born in 1852, and inherited a love of natural science from his father, a gentleman well known in engineering circles, as well as an enthusiastic naturalist and a microscopist of no mean reputation. He was educated first at a private school, and in 1871 entered St. John's College, Cambridge, where he was one of the earliest students of that school of biology of which he afterwards became so distinguished an ornament. In 1876 he obtained the entrance scholarship in natural science at St. Bartholomew's Hospital, and entered upon the study of medicine. It is hardly too much to say that this step was taken as a *pis aller*. He looked forward with anything but satisfaction to the life of a medical practitioner, and when, in 1879, he was elected to the newly-created chair of zoology in the Owens College, he entered with delight upon a career devoted to the advancement of his favourite science.

As might have been expected from the friend and companion of Balfour his first work was embryological, and consisted of a series of papers on the Cranial Nerves, published in the *Journal of Anatomy and Physiology* and the *Quarterly Journal of Microscopical Science* between the years 1877 and 1881. Though in matters of detail these papers may need correction, and though the "Segmental Value of the Cranial Nerves" is as much open to discussion as it was when Marshall wrote his thesis, these memoirs were at the time solid contributions to our knowledge, and have furnished a basis upon which other men have wrought. The culmination of his work in this direction has been the great work on "Vertebrate Embryology," of which an appreciative notice appeared in these columns so recently that it is not needful to do more than allude to it.

In 1881 the dredging operations of the Birmingham Natural History Society gave him the opportunity of studying the Pennatulida, and in the following year a report upon these animals was issued under the joint authorship of himself and his father. In this and in his subsequent papers on the "Pennatulida of the *Porcupine* and *Triton* Expeditions," and of the "Mergui Archipelago," written partly alone and partly in conjunction with Dr. G. H. Fowler, he carefully elaborated the distinctions between the various forms of zooids and traced the relationships of the genera on morphological grounds. Strong reasons were adduced for dissenting from the classification propounded by Kölliker, though Marshall never considered that he had enough material at command to justify him in proposing an alternative arrangement. On the whole it is probable that these memoirs will form his most lasting contribution to zoological science.

A paper on "The Nervous System of Antedon," containing the results of an Easter vacation spent at Naples, was valuable as establishing beyond question the views of the Carpenters regarding the nervous function of the central capsule and axial cords of Crinoids, but it is still more interesting as an example of Marshall's clear and logical method.

Marshall was a born teacher; his mind was of that rare order which not only sees a problem clearly itself, but is cognisant of every step taken in understanding it, and hence is able to enter into the position of those who approach it for the first time, and to see where their diffi-

culties will lie. His lectures were illustrated not only by wall diagrams, prepared by himself, but by sketches on the blackboard drawn with the clear decided stroke of a master-hand whilst he was talking. He was second to none in appreciating the importance of drawing as a means of fixing the details of a structure upon the student's mind, and it was his custom to offer annually a prize for the best note-book produced by a member of the class.

In his own investigations it was his practice to begin with the illustrations, and in this way the whole of the figures in his "Vertebrate Embryology" were drawn before a line of the text was written. This power of clear exposition and his long experience as a teacher rendered him a singularly competent writer of text-books, as is evidenced by "The Frog," and "Practical Zoology," each of which has passed through several editions.

His powers as a teacher and his powers as an athlete rendered him extremely popular with the students; his advice was often sought and was valued because it was always candid, whilst his geniality and kindliness were such that his most outspoken criticism never gave offence.

It is no disparagement, however, to his powers as a scientific investigator and as a teacher, to say that his greatest distinction was his capacity for organisation, though this was as yet only known to those associated with him in administrative work; it is not too much to say that the great success which attended the Manchester meeting of the British Association was mainly due to his efforts as local secretary, whilst his services first as secretary and then as chairman of the Board of Studies rendered no small aid to the Victoria University in the early stages of its growth.

The University Extension movement in Lancashire and Cheshire loses one of its most ardent supporters. Though well aware of the necessary failings of this method of imparting instruction, he was firmly persuaded of its usefulness as a means of stimulating an interest in intellectual studies. He was an ideal Extension lecturer; his singularly lucid style enabled him to expound difficult biological problems to large popular audiences, whilst the truths he taught were indelibly impressed upon his audience by the striking and generally humorous language in which they were couched.

Marshall was elected a Fellow of the Royal Society in 1885, and served upon the Council for the year 1891–2. By his death the scientific world loses a conscientious and brilliant worker; the college and university a successful teacher and administrator; but what of those who are privileged to be his friends? He was a most stimulating influence in work, and a cheery companion in pleasure, whose geniality was never known to be ruffled by ill-temper or irritation. He concealed a deep seriousness beneath a jocular and almost boyish demeanour and phraseology, and whilst rejoicing in an unbounded flow of animal spirits himself, the sorrows of others touched him to the quick and called forth his practical sympathy. Science will progress and the college and university hold on their course but the place of our friend can never be taken by another.

NOTES.

IT is with deep regret that we announce the death of Prof. Hertz, the eminent investigator whose work marks an epoch in the history of electrical science. The information comes as a surprise to us, and we are grieved that one from whom so much more might have been expected has been cut off in the prime of his life. The gap produced in the ranks of scientific investigators by his death will not readily be filled.

PROF. P. VAN BENEDEN must be added to the list of men of science who have recently passed away, and whose loss we mourn. He has just died at Louvain, at the age of ninety-three, but his works live and will always do honour to his name. He was a member of the Brussels Academy of Sciences, and had been professor at Louvain University for nearly sixty years.

WE regret to record the death of Prof. Forchhammer, the well-known archæologist; of Prof. K. L. Michelet, Berlin at the age of ninety-two; of Dr. S. Guttmann, Geheimer Sanitäts-Rath, and editor of the *Medicinischen Wochenschrift*; and of Dr. L. Krahmer, Ordinary Professor of State Medicine in Halle University.

BY the death of Dr. George Gordon, natural history in the north of Scotland has lost one of its most enthusiastic and oldest supporters. He died at the advanced age of ninety-two years, on December 12, after working nearly three-quarters of a century in the cause of science.

A COMMITTEE of eminent men of science, art, and literature, with M. Pasteur at its head, has been formed in Paris for the purpose of raising the funds to erect a monument to the memory of the late Dr. Charcot.

DR. R. BRAUNS has been appointed Professor of Mineralogy in the Darmstadt Technical High School.

A BOTANIC garden and arboretum has been established at Buenos Ayres, by M. C. Thays.

PROF. G. SCHWEINFURTH has started on his third botanical exploring visit to the Italian colony of Eritrea, on the Red Sea.

PROF. F. DELPINO, of Bologna, has been appointed Director of the Botanic Garden at Naples, and Professor of Botany in the University.

ONE of the bequests in the will of Mr. A. Peckover, who died last month, is the sum of £100 to the Linnean Society.

MR. F. E. IVES has been awarded the Elliott Cresson gold medal of the Franklin Institute for his system of colour photography, known as composite heliochromy.

THE Society for the Encouragement of Industry in the Netherlands offer a prize equivalent to £30, and a gold medal, for the best memoir on the production of electricity by windmills. Intending competitors must send in their schemes before July 1, to the Secretary of the Society, Haarlem, Holland.

ELECTRICAL engineers have as yet been unable to perfect a system of working tramways electrically along crowded thoroughfares. Inventors have long been engaged endeavouring to overcome the difficulties, and as an incentive to them to throw themselves into their task with renewed vigour is an announcement in the *Times* that the Metropolitan Traction Company of New York City has offered the handsome award of about £10,000 for a system of street-car propulsion which will be superior or equal to the overhead trolley system, but without possessing the objectionable feature of the trolley for crowded thoroughfares.

THE Committee on Science and the Arts of the Franklin Institute has issued a circular in which attention is directed to three awards under its control. The character and conditions of these awards are, briefly, as follows:—The Elliott Cresson Medal is of gold, and may be granted for some discovery in the arts and sciences, or for the invention or improvement of some useful machine, or for some new process, or combination of materials in manufactures, or for ingenuity, skill, or perfection in workmanship. The John Scott Legacy Premium and Medal (twenty dollars and a medal of bronze) is awarded for useful inventions. The Edward Longstreth Medal of Merit is

of silver, and may be awarded for useful invention, important discovery, and meritorious work in, or contributions to, science or the industrial arts. Full directions as to the manner and form in which applications for the investigation of inventions and discoveries should be made will be sent to interested persons on application to the Secretary of the Franklin Institute, Philadelphia.

IN the annual report just issued by the University of Edinburgh, acknowledgment is made of several benefactions. We read that a legacy of £1000 has been bequeathed by the late Mrs. Elizabeth Trevelyan for the foundation and endowment of a scholarship in engineering and mechanical and useful arts, and another bequest, by the late Mr. George Scott, of £1000 is destined for the foundation of a scholarship in arts. Since the close of the previous academic year a handsome bequest of £5000 by the late Mr. Alexander Low Bruce, to assist in the foundation of a chair of public health, has been intimated. Of very special interest and value is a collection of Arctic and other relics and curiosities, made by the late Dr. John Rae, the distinguished Arctic explorer, along with his bust, presented by his widow.

WE would call attention to a new departure in University College. During the Easter Term Dr. L. E. Hill, Assistant Professor of Physiology, will give a practical course of instruction in psycho-physiology. The course will take the student methodically over the several senses, and familiarise him with the methods by which the new branch of science known as physiological-psychology or psycho-physics determines the precise manner in which sensation varies both quantitatively and qualitatively with variations of the stimulus, of the particular portion of the sensitive surface stimulated, and so forth. This is, we believe, almost the first attempt in this country to give to students systematic laboratory instruction in those experimental methods of investigating sense-phenomena which have already borne such valuable fruit in Germany and America. As supplying an exact and practical method of measuring sensibility the course should further prove valuable to teachers and others.

THE increasing interest in psychological investigation in America is shown by the establishment of many psycho-physical laboratories, and by the formation last year of the American Psychological Association, which drew to Columbia College at its second meeting, December 27 and 28, a distinguished gathering of original investigators. The programme, besides the annual address of the president, Prof. G. T. Ladd, of Yale University, included the following papers :—The psychological standpoint, by Prof. G. S. Fullerton, University of Pennsylvania ; the case of John Bunyan, by Prof. Josiah Royce, of Harvard University ; some account of investigations at Columbia College, by Prof. Cattell ; same at Harvard University, by Prof. Münsterberg ; same at Yale, by Prof. Scripture ; experiments on visual memory, by Mr. H. C. Warren, of Princeton University ; Do we ever dream of tasting? by Prof. J. C. Murray, of McGill College, Montreal ; an early anticipation of Mr. Fiske's doctrine as to the meaning of infancy, by Prof. N. M. Butler, of Columbia College ; accurate work in psychology, by Dr. E. W. Scripture, of Yale University ; the problem of psychological measurement, by Mrs. G. H. Mead, of the University of Michigan ; the perception of magnitude and distance, by Dr. J. H. Hyslop, of Columbia ; pain and pleasure, by Mr. H. R. Marshall, of New York ; pain contrasts, by Prof. Edward Pace, of Catholic University, Washington ; the confusion of content and function in the analysis of ideas, by Prof. D. S. Miller, of Bryn Mawr College. Prof. James, of Harvard, was elected president for the ensuing year, and Princetown was named as the place of the meeting on December 27 and 28 of this year.

AT the general meeting of the Association for the Improvement of Geometrical Teaching, to be held at University College, London, January 13, a new undertaking will be proposed by the Council, viz., the establishment of a journal of elementary mathematics, to appear three times a year, and to be specially devoted to such subjects as are usually taught in secondary schools.

A COURSE of lectures on matters connected with sanitation will be given at the Sanitary Institute from January 26 to April 2. Among the lecturers are Sir Douglas Galton, Profs. Corfield, H. Robinson, A. W. Blyth, A. B. Hill, Dr. J. F. J. Sykes, Dr. A. Newsholme, and Dr. Hamer. The lectures have been arranged for the special instruction of those desirous of obtaining a knowledge of the duties of sanitary officers.

ON Tuesday next (January 16), Prof. Charles Stewart, the newly elected Fullerian Professor of Physiology in the Royal Institution, will begin a course of lectures on "Locomotion and Fixation in Plants and Animals." The Friday evening meetings will begin on January 19, when Prof. Dewar will discourse on the "Scientific Uses of Liquid Air."

THE annual general meeting of the Royal Meteorological Society will be held on January 17, when the report of the council will be read and the election of officers and council for the ensuing year will take place. The president of the society will deliver an address on "The Climate of Southern California."

A PERIOD of very severe weather has recently been experienced over these islands and the whole of Western Europe. On the 1st inst. an anticyclone lay over Scandinavia, and subsequently spread over the northern parts of this country, causing frost in many places, while snow showers occurred in England, accompanied by bitter easterly gales. For some days the frost and snow contiuued with increased intensity. The reports issued by the Meteorological Office show that on the morning of the 6th inst. the minimum temperature in South London fell to 13°, while on the previous day a temperature of 16° was recorded at Jersey, being 22° below the average minimum for January, and at Biarritz a reading of 14° was recorded on the 4th, being 20° lower than the reading at Bodö in Norway, within the Arctic Circle. Towards the end of the week the easterly gales had subsided in the south-east, but had spread to the northern parts of the kingdom. On Saturday morning the Meteorological Office reported a temperature of 5° in the Midland Counties and 6° in the centre of Ireland, but later information in the *Weekly Weather Report* shows that the absolute shade minimum recorded was minus 4° at Braemar and in the Midlands on that day. With reference to the temperature in the north-west of London, Mr. Symons recorded 13°·1 on the 5th, and a maximum temperature of 18°·4. His long series of observations shows that the severity of the night of the 4th and 5th was only exceeded three times in the last thirty-five years, viz. December 25, 1860, January 4, 1867, and January 17, 1881 (the day preceding the blizzard); while as regards the maximum, there has been only one day as severe during the same period, viz. January 4, 1867, when the temperature did not exceed 16°·9. The frost continued until the morning of the 8th, when a deep depression appeared off the south-west of Ireland, causing southerly winds and a considerable rise of temperature, and by Monday evening a thaw had set in generally.

OWING to delay at the Government Printing Office, Mr. H. C. Russell, the Government Astronomer for New South Wales, has only just been able to issue the results of rain, river, and evaporation observations made in that colony in 1892. In addition to the usual matter, the report contains the results of an attempt to determine the average rainfall of Australia. It will

be many years before the rainfall of Australia will be measured in all parts, but taking the values already obtained, and weighing them in proportion to the area of each colony in which they were made, the average annual value of the rainfall for the whole of the mainland of Australia comes out as 21·15 inches. Another matter which Mr. Russell has investigated is the effect of altitude upon temperature. In works of reference it is usually stated that a rise of 300 feet causes a fall of 1° Fahr., but this quantity must evidently vary with the locality. A comparison of the average temperatures at ten different places with that of Sydney, making an allowance at the rate of 1° Fahr. for a difference of one degree of latitude, gave 344 feet as the mean elevation required to produce a fall of 1° Fahr. The report concludes with an average rainfall map, constructed on the plan described in these columns on December 21; a new rainfall map for the year; a map showing the monthly distribution of rain over each square degree of New South Wales, and curves showing the height of the western rivers of that colony throughout 1892.

THE *Transactions* of the Devonshire Association for the Advancement of Science for 1893 contain a good account of the climate of Torquay, by A. Chandler, from trustworthy instruments. This health resort is favoured by a large amount of sunshine; dividing the year into two periods the summer has an average of 43·4 per cent., and the winter 30·5 per cent. of the possible amount. The average mean shade temperature is 50°·2, and the mean annual range 11°·4. The mean temperature of summer is 56°·5, and of winter 43°·8. The highest summer temperature during the year 1892 was only 78°·2, and the lowest winter temperature was 22°·4. The mean annual rainfall for twenty-five years, 1864–88, was 37 inches; June is generally the driest month, with an average of about 2 inches, and January the wettest, with a mean of a little over 4 inches. The prevalent winds are warm, being from south-west, and the town enjoys great freedom from storms. The observations are now organised and provided for by the Town Council.

WRITING upon the persecution of the Great Skua (Stercorarius Catarrhactes) in the *Annals of Scottish Natural History* for January, Mr. W. E. Clarke points out that a fact worth remembering in the history of those birds which have become extinct within the present century, is that their extermination had, in all instances, become an accomplished fact for several years before such was realised to be the case. In order to lead ornithologists to do something to prevent the Great Skua from a similar fate, Mr. Clarke gives an account of the persecution to which the bird is subject, and the wholesale stealing of its eggs. The evidence he brings forward shows that unless some measure of protection is immediately afforded to the Great Skua, this fine bird must soon cease to exist in Europe.

MISS E. A. ORMEROD contributes to the *Times* of Monday some observations on insect attacks upon crops and trees in this country during last year. She points out that the attacks of the year were much influenced by the exceptional deficiency of rainfall in the early half of 1893, from March onwards, and by other weather peculiarities. With regard to the imported locust appearances, the specimens which reached her alive proved to be of a South European species, which is not gregarious, and in its own country, though of large size, is known to do no appreciable damage. From the climatic requirements of locusts, therefore, and also from recorded experience, there does not appear to be any reason to fear even a possibility of locusts effecting a settlement in this country. It is pointed out by Miss Ormerod, however, that the presence of locusts in great quantities in fodder might be detrimental to the health of animals fed upon it.

ANOTHER note on locusts, more or less connected with the above, is contained in a statement recently issued by the Government of India (*Agricultural Ledger Series*, No. 2, 1893). Dr. Günther suggested to the Government, some time ago, that dried locusts might be used for insectivorous cage-birds and game-birds which are now reared at great expense upon ants' eggs. His letter was submitted to Mr. E. C. Cotes, of the Indian Museum, Calcutta, who has reported favourably upon it, but thinks there would be a difficulty in keeping up the supply from India at the present time. But though the invasion of India by the locust *Acridium peregrinum*, Oliv., is now practically at an end, Mr. Cotes says that Northern Africa, which was badly invaded in 1892 by the same insect, and is still infested, might offer a favourable ground for experiment.

THE silk-spider of Madagascar forms the subject of an interesting article in *Die Natur*, by Dr. Karl Müller. Its native name is Halabé, meaning great spider. This Halabé, or *Nephila Madagascariensis*, spins threads of a golden colour, and strong enough, according to Maindron, to hang a cork helmet by. The female spider may attain a length of 15 c.m., while the male does not exceed 3 c.m. A single female individual, at the breeding season, gave M. Camboué, a French missionary, some 3000 m. of a fine silken thread, during a period of about twenty-seven days. The thread was examined with a view to creating a new industry. Specimens tested at a temperature of 17° C. showed an elongation of 12·48 per cent. under a weight of 3·27 gr. Small textures woven of these threads are actually used by the natives for fastening flowers on sunshades, and for other purposes.

PROF. J. WIESNER, who has recently been studying the influence of artificial rain upon European and exotic plants, gave an account of his results at a recent meeting of the Vienna Academy. Some of the plants, called by Prof. Wiesner *ombrophobe*, can only for a short time stand continuous rain, and soon shed their leaves and decay. Others, called *ombrophil*, can stand it for months together. Plants growing in dry places are, as a rule, ombrophobe, but the reverse cannot be said of plants growing under wet surroundings. Leaves appear to gain in power of resisting rain as they develop, and to reach a climax in this respect at the period of their greatest vital activity, after which they lose much of that power. Leaves which can be wetted by water are usually ombrophil, those which cannot are usually ombrophobe, but in cases where leaves are both ombrophobe and easily wetted, they are extremely sensitive to rain. Prof. Wiesner thinks that ombrophobe leaves are enabled to resist the putrefactive action of water, especially at high temperatures, by certain antiseptic substances which they contain. The same may be said of hydrophil roots and submerged parts of aquatic plants.

THE edible lichen of Japan, known as "iwatake," is described in the *Botanisches Centralblatt* (1893, No. 45) by Dr. M. Miyoshi, under the name *Gyrophora esculenta*, sp.n. Its commercial value is due to the large amount which it contains of starch and of some gelatinous substance; and it is also extensively used in Japanese cookery as a condiment, having a pleasant flavour and being free from purgative properties. In some parts of Japan, especially the mountainous districts, it completely covers the moist granite rocks. After drying it is sent into the towns, and a large quantity is annually exported.

IN a recent number of the *Electrical World* (of New York), Lieut. F. Jarvis Patten has described a novel method of obtaining sinusoidal alternating currents of very low frequency. The apparatus, which the inventor calls a "liquid commutator," consists of a circular vessel, provided with two conducting electrodes fixed at the opposite extremities of a diameter. A con-

tinuous current is passed from one of these electrodes to the other, through the liquid contained in the vessel, the strength of the current being controlled by an internal resistance. A vertical spindle at the centre of the trough carries a revolving arm provided with conducting plates or electrodes at its extremities. These plates are insulated from one another, and are connected to two ring contacts carried by the central spindle. Two brushes bear on these rings, and convey the alternating current. By suitably altering the connections and electrodes, it is possible in the same manner to obtain multiphase currents. The author finds that the currents obtained are practically sinusoidal, and he suggests that they will be of considerable physiological use.

AT a recent meeting of the Société Française de Physique, M. Hurmuzescu showed some experiments on electrical convection in air. He finds that if you cause dissymmetry between the two discharging knobs of a Wimshurst electrical machine, by fixing a point to one of them, then, on placing a sensitive gold-leaf electroscope at a distance of about two metres, when the machine is worked, the discharging knobs being separated, the electroscope becomes charged. The electroscope becomes more highly charged when it is fitted with a point than when it has only a varnished ball at the end of its electrode. That the charge is not due to induction, but to convection through the air, is shown by the fact that the interposition of a metallic screen does not interfere with the effect, while if the electroscope is covered over by an insulating shade no electrification is observable. In addition, it is found that the charge on the electroscope is of the same sign as that of the terminal of the machine on which the point is fixed. The most marked and rapid results are obtained when the point on the machine is negatively electrified, while no effects are observed if the point is turned towards the plates of the machine.

AN account of Victor Schumann's successes in photographing rays of very short wave-lengths is given in No. 50, of the *Naturwissenschaftliche Rundschau*. These successes are entirely due to the elimination of absorption by the material used in the prisms and lenses and, what is especially noteworthy, of the layers of air intervening between the luminous source and the plate used for photographing the spectrum. This elimination has resulted in the exhaustive exploration of the hitherto doubtful ultra-violet region between 231·4 and 185·2 $\mu\mu$, and the annexation of the region down to 100 $\mu\mu$ to the known spectrum. For this it was necessary to get rid of the absorption due to the film of gelatine in which the sensitive silver salt was embedded, and this was accomplished by the substitution of a pure silver bromide plate. The camera, the spectroscopic apparatus, and the spark tube were all connected together and exhausted. The very first exposure on the hydrogen spectrum showed that the known radiations of that gas only represent a portion of its total radiance. The newly-traced portion turned out to be extremely rich in lines, with a maximum at about 162 $\mu\mu$, and consisted of fifteen groups of lines disposed pretty evenly, containing altogether about 600 lines, with intensities decreasing from the maximum in both directions, rapidly at first, and then very gradually. The wave-lengths of these lines are as yet undetermined. Provisionally, that of the smallest wave-length recorded is estimated at 100 $\mu\mu$. The spectra of aluminium, cadmium, cobalt, and other metals end at about 170 $\mu\mu$. A layer of normal air 1 mm. in thickness appears capable of absorbing all radiation of smaller wave-length than that. Dry gelatine absorbs eagerly all waves beyond 217 $\mu\mu$. Quartz is not suitable for prisms and lenses, and white fluor-spar is, so far, the only material that answers all requirements. The accurate determination of the new wave-lengths, the further investigation of the absorption due to air, and the further extension of the ultra-violet region, are the problems which Herr Schumann is now working at.

IN a note published in NATURE on July 20, attention was drawn to the manner in which the virulence of the typhoid bacillus may be increased by the products of other organisms being inoculated along with it into animals. In an elaborate paper, recently published in the *Annali dell' Istituto d'Igiene di Roma*, vol. iii. 1893, p. 117, Roncali shows how the virulence of the tetanus bacillus may be intensified by similar means. Thus an animal inoculated with this organism usually succumbs in three days; if, however, the soluble products of this bacillus be accompanied with those of some other organism, death ensues with tetanic symptoms in from 12–26 hours. It was also found that if by some means or other the power of resistance inherent in the animal was first diminished, the action of the tetanus toxine was greatly accelerated. This condition of diminished resistance was obtained by either first inoculating some other organism, or by introducing putrid infusions of meat or vegetables in themselves proved to be perfectly harmless to the animal in question. To further illustrate this point, symptoms of chronic tetanus were induced in animals by the inoculation of the soluble products of the tetanus bacillus obtained after from 3–4 days' growth. After from 8–10 days, if pathogenic or non-pathogenic organisms were introduced, the animals died in from 16–18 hours, whilst if they were not subsequently interfered with, they usually recovered in from 20–35 days. In the course of these investigations the interesting discovery was made that the bacillus of rabbit septicæmia, which is usually non-pathogenic to mice, may be rendered fatal to the latter by cultivation on agar-agar containing the soluble products of the tetanus bacillus. These experiments indicate how harmless saprophytes, such as the *b. prodigiosus*, may under given conditions become the servants of disease organisms, either by diminishing an animal's power of resistance, and so preparing the way for the entrance and work of pathogenic bacteria, or by hastening the lethal action of the latter by subsequent intrusion into the system of the infected animal.

WE have received three fascicules of the forthcoming volumes of the *Memoirs* (*Zapiski*) of the Russian Geographical Society. One of them contains D. Pokotilov's elaborate paper, "U-tai, its Past and Present," given to the description of the holy mountain of the Buddhists and its numerous monasteries. M. Pokotilov has followed the same route as Dr. Jos. Edkins ("Religion in China"), and also describes his journey from Pekin to the U-tai Mountain; but he also gives a detailed description of the Buddhist sanctuary, and the history of the development of Buddhist monasteries at this spot. The learned Russian scholar has utilised, moreover, the Chinese works devoted to the same subject. Taken in connection with Prof. Pozdneev's large work, "Sketches of the Life of Buddhist Monasteries and Buddhist Clergy," lately published in the *Memoirs* of the same Society (Ethnography, vol. xvi., 1887), M. Pokotilov's paper is a very valuable addition to the literature of the subject. Another fascicule of the *Zapiski* (Geography, vol. xv. No. 3) contains F. Schwartz's report on his astronomical, magnetical, and barometrical observations in Bokhara, Darvaz, Karateghin, and Russian Turkestan, made in 1886. A third fascicule (Statistics, vol. vii. No. 2) contains a detailed description of the Eritrean colony of Italy, by M. A. Troyansky.

THE Physical Society of London has just issued the third part of vol. xii. of its Proceedings.

THE first part is published of the new *Flore de France* (including Corsica and Alsace-Lorraine), by MM. G. Rouy and J. Foucaud.

WE have received No. 8 of the first volume of "Contributions from the U.S. National Herbarium." It is chiefly occupied by the description of American grasses, a large number of new species being described.

THE current number of the *Asclepiad* (vol. x. No. 39), edited by Sir B. W. Richardson, F.R.S., contains a good account of the works of Robert Boyle, and an autotype of that eminent investigator, from an engraving by R. Woodman.

THE second edition of Clowes' and Coleman's "Quantitative Analysis" (J. and A. Churchill) is about to be issued. The authors have thoroughly revised the book, and have introduced many recent modifications in processes, as well as new methods of analysis.

THE *Journal of the Royal Statistical Society* (part iv. vol. lvi.) has been received by us. It contains, among other papers, the presidential address delivered by Mr. Charles Booth in November last, and that given by Prof. Nicholson before the Economic Science and Statistical Section of the British Association at the Nottingham meeting.

WE have received "Eau Sous Pression," by M. F. Bloch, being a new volume in the Aide-Mémoire Series published by Gauthier-Villars, Paris. The early chapters in the book are devoted to enunciating hydrostatic and hydrodynamic principles, and stating the general theory of pumps, hydraulic rams, and accumulators. The subject is then treated from a practical point of view. The book contains thirty illustrations in the text, and does credit to an excellent series.

The Technical Instruction Committee of the County Council of Cumberland has issued a Directory of the Science and Art Classes, &c., under its control. We learn from this source that the average attendance of students at science classes held under the committee's jurisdiction is 1328. The subject that obtains the highest average is theoretical chemistry; then come agriculture, mathematics, plane and solid geometry, and physiography. Sound, light, and heat shows, by far, the lowest number of students, the average attendance for the whole county being only eight.

THE third volume (Series 3) of the *International Journal of Microscopy and Natural Science* has been published. The journal is the organ of the Postal Microscopical Society of London, which has for its object the circulation, study, and discussion of microscopic objects. The volume just received contains a large amount of information of use to microscopists, and several excellent papers, notably one on polarised light and its applications to the microscope, by Mr. G. H. Bryan, and a translation from *La Diatomiste* of Dr. Miquel's long article on the artificial cultivation of diatoms. The journal is well illustrated and does credit to the society the proceedings of which it reports. We have noticed two misprints, one on p. 8, where "Leek" is printed instead of Lick, and on p. 69 "Wills" is printed instead of Wells.

A USEFUL series of "Handbooks of Commercial Products" has been provided to the Imperial Institute by the Government of India. The books contain descriptions of the economic products of India, and among several of them recently received is one on Indian coal, in which a large number of facts concerning the geology and working of the coal districts are brought together. The iron resources and iron industries of the southern districts of the Madras Presidency are described in another of the handbooks, the account being accompanied by a plate showing the process adopted for the manufacture of wrought iron. The furnace employed is roughly circular in horizontal section, four feet high, two feet in diameter at the base, and only nine inches in diameter at the throat. Two other handbooks of interest to us summarise the present state of knowledge concerning the characters and occurrence of Indian micas and steatite.

A NUMBER of new reactions of formaldehyde, resulting in the preparation of several new compounds, are described by M. Henry in the *Bulletin de l'Académie Royale de Belgique*. This lowest number of the series of aldehydes, HCHO or $O=CH_2$, appears to be endowed with very considerable chemical energy, as indicated by the readiness and frequently the violence with which it reacts with a large number of substances. The reactions now described are those which occur between formaldehyde and the primary and secondary amines. If a solution of methylamine is added to one of formaldehyde, in small portions at a time, a very energetic reaction occurs with evolution of so much heat that great loss occurs unless the vessel in which the operation is performed is surrounded by a freezing mixture. When the reaction is complete, the two substances being then present in equivalent quantities, the addition of solid potash precipitates methyl methylenamine, $H_2C=N-CH_3$, from the solution. This substance is readily purified, and proves to be a colourless mobile liquid, readily soluble in water, and boiling at 166°. At the temperature of a freezing mixture of ether and solid carbon dioxide it solidifies, and may be melted again at −27°. The ethyl compound may be similarly obtained, and is likewise a liquid; it boils at 207–208°, and melts after solidification by ether and solid carbon dioxide at −45°. Two molecular equivalents of dimethylamine react with even greater avidity in aqueous solution with one molecular equivalent of formaldehyde, and the reaction can only be safely carried out at a very low temperature. The product is tetramethyl methylenediamine $CH_2\begin{matrix}N(CH_3)_2\\N(CH_3)_2\end{matrix}$, a colourless and very mobile liquid which fumes strongly, dissolves in water, and boils at 85°. Ether and solid carbon dioxide will not solidify it. The tetraethyl compound, prepared in an analogous manner, is also a fuming liquid; it boils at 168°. All these compounds are insoluble in strongly alkaline liquids. They readily absorb water, like the amines, formaldehyde and the substituted ammonia being regenerated. A somewhat curious fact is observed in connection with the boiling-points. Methyl methylenamine $CH_2:NCH_3$ boils at 166°, and methyl isocyanate $CONCH_3$, the analogous oxygen compound, at 43°; so that the replacement of two atoms of hydrogen by one of oxygen is accompanied in this case by a reduction of the boiling point by 123°. On the other hand, while the compound $CH_2\begin{matrix}N(CH_3)_2\\N(CH_3)_2\end{matrix}$ boils at 85°, the corresponding oxygen compound tetramethyl urea boils at 177°, nearly a hundred degrees higher.

IN a further communication to the *Bulletin* of the Belgian Academy, M. Henry describes a new mode of preparing halogen substitution products of the oxides (ethers) of the alkyl radicles. The monochlorine derivative of methyl ether $CH_2Cl\cdot OCH_3$ was prepared in 1877, by Friedel, by chlorination of the ether. It is now shown to be much more readily obtained by mixing a concentrated aqueous solution of formaldehyde with methyl alcohol and saturating the cooled solution with hydrochloric acid gas. The compound separates as a colourless liquid layer at the surface of the solution, and by distillation the pure substance is at once obtained, boiling at 60°. The monobromine derivative may be obtained in a precisely similar manner, and proves to be a pungently-fuming liquid, boiling at 87°. The iodine compound is also afforded by the analogous reaction with hydriodic acid, the pure liquid boiling at 124°, but, in addition, the di-iodine

derivative $CH_2I{\cdot}O{\cdot}CH_2I$ is simultaneously formed. Incidentally M. Henry observed that phenol reacts in a most violent manner with formaldehyde, great heat being evolved, and a remarkable porcelain-like substance being produced which is insoluble in all the usual solvents.

THE additions to the Zoological Society's Gardens during the past week include a Black-handed Spider Monkey (*Ateles ater*, ♀) from Eastern Peru, presented by Mr. L. Clarke; a Coot (*Fulica atra*) European, presented by Mrs. L. Spender; two Wedge-tailed Eagles (*Aquila audax*) from Australia, presented by Mr. F. W. Burgess; a Long-billed Butcher Bird (*Barita destructor*) from New Holland, deposited; a Salvin's Amazon (*Chrysotis salvini*) from South America, two Purple-capped Lories (*Lorius domicella*) from Moluccas, purchased; a Yak (*Pœphagus grunniens*) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

HARVARD COLLEGE OBSERVATORY REPORT.—In this, the forty-eighth annual report to the President of the University, Prof. Pickering, the director of the Astronomical Observatory of Harvard College, has a fine record of work to refer to, which has been carried out during the twelve months ending October 31, 1893. We make the following brief extracts from the accounts given of the various branches of work done in the several departments. The East Equatorial was on the whole worked by Mr. O. C. Wendell, and employed for the systematic observation of variable stars upon the system lately adopted. Photometric observations of Jupiter's satellites (twenty-five in number) were made; forty-eight series of wedge photometer observations (3354 measurements) for determining the brightness of 1118 stars occurring in the Durchmusterung, were also made. Among other uses of this instrument were the observations of comets, measurements with the polarising photometer, &c. The Meridian Circle has been, as usual, at work under the direction of Prof. W. Rogers, while good progress has been made in the reductions of the observations of the southern stars with the meridian photometer. The observing list for the latter observations contains about 6000 stars, and excluding the 4000 already contained in the Harvard Photometry, three quarters have now been made. Mr. W. Reed, with the West Equatorial, on eighty-seven evenings has made observations on variable stars (489), comparison stars (1318), and ten on the brightness of Comet Holmes.

With regard to the Henry Draper Memorial, Mrs. Fleming has given us, as usual, her list of stars with peculiar spectra, and her examination has resulted in the discovery of the new star in Norma. In addition to a classification of the 20149 spectra of stars for the new catalogue, work has been done with the 8-inch and 11-inch, resulting in the production of 2424 and 1037 photographs respectively. A most interesting series (213 photographs) of β Aurigæ has also been obtained.

In the Boyden Department, in addition to an expedition to observe the total solar eclipse in April last, important work was done by the 13-inch telescope, which was devoted to a study of the members of the solar system, an account of which has been previously referred to in this column. Prof. Bailey, the director of the third expedition, began work on April 4, and with an 8-inch and 13-inch telescope has obtained 1516 and 852 photographs with these two instruments respectively; some of these pictures show some very remarkable southern clusters. This observatory has also a meteorological station on Mount Chachani, 16,650 feet, the highest in the world; a second one has now been established on the volcano El Misti, at an elevation of 19,200 feet, with self-recording instruments. The Bruce photographic telescope will now be soon completed and ready for work, but the Bruce transit photometer has already made some progress towards the observations of tenth magnitude stars as standards for faint stellar magnitudes. Zodiacal phenomena have also been systematically observed. The new brick building for the thirty thousand glass photographic plates is finished, and the plates have been transferred. In his concluding remarks Prof. Pickering alludes to the difficulty, now becoming more and more significant every year, with regard to the observation of faint objects, owing to the increasing number of electric lights in the neighbourhood. An "electric tram" trouble seems also approaching a focus in the near future. We hope Prof. Pickering will successfully override these difficulties.

THE "GEGENSCHEIN."—In order to find out the origin of this peculiar phenomenon an effort has been made to obtain observations as nearly contemporaneous as practicable, and made at widely separated points. The distribution of light in the zodiac, and particularly of the slight maximum nearly opposite the sun, and known as "Gegenschein," or Counter-glow, has for some time past attracted the attention of astronomers, and we hope the present systematic attempt will be rewarded with successful results. Those cooperating in this work are Prof. Barnard, of the Lick, Prof. Bailey at Arequipa, Prof. Searle and Mr. Reed at Strafford, Vermont, and Mr. Douglass at Cambridge, U.S.A. Prof. Barnard, after describing the general appearance of this phenomenon (*Astr. Journal*, No. 308), besides noticing the change of form and its connection with a zodiacal band, finds that his observations show that the "Gegenschein" lags behind exactly opposite the sun, or, in other words, that its longitude is not quite 180° greater than that of the sun. His numbers are:—

From	λ—⊙.	β.	No. obs.
1883–1887	179°·4	+0°·4 ...	16
1888–1891	179°·4	+1°·3 ...	16
Sept. and Oct. 1893	179°·6	+0°·5 ...	22

His observations show no decided parallax to the object, but an appreciable north latitude, as seen from the value of β in the table above, will be noticed.

Prof. Barnard believes that the latitude of the "Gegenschein" and the lagging in longitude to be due to "atmospheric absorption, and that the object is exactly opposite the sun, and that it lies in the ecliptic, and if its centre were a definite point the position of the sun could be accurately determined from observations of the 'Gegenschein' by changing the sign of the declination and subtracting twelve hours from the Right Ascension."

GEOGRAPHICAL NOTES.

THE Arctic expedition planned by Dr. Stein, of the U.S. Geological Survey, as the first of a series for the gradual exploration of the Arctic regions from a base in Ellesmereland (see NATURE, vol. xlix. p. 18), is being actively prepared. According to Reuter's agency the command of the expedition has been offered to Baron Nordenskiöld, who has contributed £250 to its fund and has arranged by cable to keep a place open for a Swede on the staff. Dr. Stein has agreed to the latter proposal, and has stated that his first duty will be to search for the Swedish naturalists Björling and Kalstennius, whose tragic story has been briefly told in this column (p. 85). The possibility that the unfortunate party was able to reach the Eskimo of Ellesmereland and live with them for two years is very slight, but as long as the faintest chance remains it is satisfactory to find that arrangements are being made for a search and possible succour.

M. E. A. MARTEL, whose researches on the subterranean watercourses of France and Greece are well known, has been investigating the Adelsberg Grotto and other *karst* phenomena of Carniola, in company with Herr Putick. They were able to solve conclusively some points in the hydrology of the river Piuka, and found their way into parts of the Adelsberg cavern never before reached, proving that the whole length of the underground passages in connection with it is not less than 10 kilometres.

WITH the publication of vol. xix., dealing with South America, M. Elisée Reclus' great work, "Nouvelle Géographie Universelle: La Terre et les Hommes," has been completed. Twenty years have elapsed since the first volume was published, and these years have seen immense advances of geographical knowledge; but by the device of treating the less known continents at the end of the work, it has not fallen seriously out of date. Its great features are the philosophic grasp of the relation of man to his natural surroundings, and the working out of this relation for each continent and country. It is unfortunate that the state of public feeling on the continent makes it impossible for the University of Brussels to carry out the appointment of M. Reclus to a professorship there (see NATURE, vol. xlvii. p. 327 on account of his political views.

AT a meeting of the Royal Scottish Geographical Society, held last week at Edinburgh, with Prof. J. Geikie in the chair, to consider the question of Antarctic research, the following resolution by the council of the Society was read:—"That at this meeting, held for the discussion of Antarctic research, the Royal Scottish Geographical Society resolves to give its hearty support to the promotion of further exploration in the Antarctic. The Society's council is of opinion that at the present time a properly equipped Government expedition would, with the increased advantages of steam and modern appliances, have every prospect of successful explorations in the South Polar regions. The council is also convinced that the additions which might be made to our knowledge of climatology, terrestrial magnetism, geology, and natural history, would be of such practical scientific value as to fully justify the equipment of such an expedition at national expense. Towards the promotion of this object the council considers it desirable to submit a memorial on this subject to her Majesty's Government, and in this action they invite the cooperation of all the leading scientific societies of Scotland. To this end the Society appoints an Antarctic committee, consisting of Dr. John Murray, Prof. James Geikie, Dr. Buchan, and Mr. J. G. Bartholomew, together with the delegates of the other scientific societies, with instructions to draft such a memorial and take such steps towards the promotion of Antarctic exploration as is deemed desirable." A committee of the Royal Geographical Society was formed on the occasion of Dr. Murray's paper (NATURE, vol. xlix. p. 112), and has already been at work for some time with a view to bring the whole question of Antarctic exploration before Government. The course of action of this committee we understand to be the memorialisation of the Royal Society, requesting that body to take the lead in approaching the Government after ascertaining the feeling of all the leading scientific societies of the United Kingdom.

THE RISE OF THE MAMMALIA IN NORTH AMERICA.[1]

II.

Primitive Trituberculism.

There is a very general tendency among the vertebrates as a whole, fishes and reptiles as well as mammals, to form what are called "triconodont" crowns by the addition of lateral cusps to simple cones. In the mammals alone, these three cusps pass into higher stages of evolution, through what is called "trituberculy," in which these cusps form a triangle. The discovery of primitive widespread trituberculy by Cope was a great step forward. In looking over the odontographies of Cuvier, Owen, Tomes, and Baume, we find there is no suspicion of this common type around which the highly diverse mammalian molars centre. The molars of the clawed and hoofed mammals can now be compared, as we compare the hand or foot of the horse with that of the cat, because they spring from a common type. All the specialised mammalian series—ungulates, primates, carnivores, insectivores, rodents, marsupials—are found playing similar yet independent adaptive variations upon one type. We thus have a clue to the comparison of all molars with each other and with the reptile cones; take the human grinders, for example. The anterior outer cusps in the upper jaw, and the anterior inner cusps in the lower jaw, are homologous with each other and with the reptilian cone. Leaving aside for the moment Multituberculates and Monotremes, every known triassic, jurassic, cretaceous and basal eocene mammal (excepting Dicrocynodon) is in some stage of trituberculy; all the known cretaceous molars are simple triangles above; all later fossil mammals also converge to trituberculy, until in the lowest eocene every molar is tritubercular, and the early stages of divergence are so similar that it requires a practised eye to distinguish the molar of a monkey from that of a horse. Embryology supports the evidence of these fossil series. Thanks to the recent admirable researches of Röse and Tæcker, we find in the primates, ungulates and marsupials, that in the calcification of its dental caps every molar is heralded by *three cones placed in a triangle*, and in the lower jaw these three cones invariably appear in the same order (protocone, paracone, and metacone) in which they arose during the remote geological periods.

Continued from p. 238.

It is necessary to mention this overwhelming palæontological evidence, because "trituberculy" is still not universally recognised; Fleischmann and others have questioned the homologies of the upper and lower triangles, and two able writers, Röse and Forsyth Major, have independently proposed an opposition theory that "multituberculy" or "polybuny" is the mammalian archetype, the latter author believing trituberculy has become a "dogma." So far, however, from there being any decline of evidence, I am now able to add the Cretaceous mammalia to the tritubercular lists and bring forward evidence that the multitubercular molar instead of being primitive was derived from the tritubercular; moreover, all the researches I have been quoting tend to draw the mammals without exception into one of three great primary forms. The haplodont form, from which Dromotherium is just emerging in the Trias, is the oldest and nearest the reptiles; the triconodont, or three cones in line, was a predominating lower Jurassic type; the tritubercular, or three cones in a triangle (trigonodont, Rütimeyer), was the prevailing upper Jurassic and later form. The final predominance of the tritubercular over the others was due to its possibilities of mechanical adaptation to work of every kind—its *potential* in evolution. Upon the polyphyletic theory of the origin of the mammals here advocated, we must admit, first, the independent evolution of trituberculy in different phyla; and second, the branching off of several great groups in the pre-tritubercular stages.

The tendency of late research is to show that all stem mammals were related in their diphyodontism, in their dental formula, and in their primitive molar form. These features point, not to a succession, but to a unity of ancestry of the Monotremes, Marsupials, and Placentals.

Divergence of the Three Groups.

The discovery of the complete double series seems to have removed the last prop from the theory of the Marsupial ancestry of the placentals, for the peculiar mode of suppression of the second series in the Marsupials has been constant since the Purbeck; this difficulty is added to the structure of the jaw, the epipubic bones, the profoundly different mode of fœtal nutrition. None the less, any conclusion we can draw now as to the primary relations of the three great groups is more or less of a "Schwindelbau," and I put together the results of these later discoveries with a full realisation of the temporary character of present conclusions.

The Permian Sauro-Mammalia (Baur) with a multiple succession of simple conical teeth divided into: A, Theromorpha, which lost the succession and in some lines acquired a heterodont dentition and triconid single-fanged molars; B, Pro-mammalia.

The hypothetical lower Triassic Pro-mammalia retained a double succession of the teeth; they became heterodont, with incipient triconid double-fanged molars; dental formula approximating 4. 1. 4–5. 8. They gave rise to three groups: I. The Prototheria which passed rapidly through the tritubercular into the multitubercular molars in the line of Multituberculates, and more slowly into trituberculy and its later stages in the ine of Monotremes. II. The Metatheria or Marsupials tended to suppress the second series of teeth, except those intercalated with the first; by this and by reduction the formula became 5. 1. 3. 4–6; the molars passed slowly through the triconodont into the typical tritubercular type. III. The Eutheria or Placentals divided early into a number of branches, in which there was heterodontism, but no uniform modification of succession.

We may distinguish four chief branches among these, as follows: (A) forms suppressing the second series in the molar region only, and acquiring a typical Eutherian dentition, 3. 1. 4. 3–4. 1. The Insectivores tended to partly suppress the anterior teeth of the second series or intercalate them with teeth of the first series; the molars became tritubercular. 2. The higher Placentals retained the succession of the first and second series as far back as the first molar; the molars entered rapidly into trituberculy and its higher stages. (B) forms retaining the double succession in part of the molar region, and retaining more of the primitive dentition, 4. 1. 4. 8. 3. The Edentates branched off from an early triconodont or tritubercular

diphyodont stage, with numerous molars, and secondarily suppressed the first heterodont series, and established a numerous homodont second series. 4. The Cetacea also branched off from a diphyodont, heterodont stage, and secondarily established a numerous homodont first series, suppressing the second series.

Breaks and Links in the Mesozoic Fauna.

By our hypothesis all three sub-classes flourished together during the American Mesozoic; the Marsupials disappeared, then the Monotremes, and by the end of the basal Eocene the Placentals were in exclusive possession of the northern continent.

Although we have great reason to congratulate ourselves upon the rapid progress of discovery, there still remain great gaps in Mesozoic time between certain horizons, and in the lineal phyletic series of both the Mesozoic and Cenozoic. For a time standard we may take advantage of the remarkably constant evolution of the Plagiaulacidæ in the Mesozoic, and of the Equidæ in the Cenozoic—as certain invertebrates are made use of in older rocks. The grooves and tubercles of Plagiaulax and the cusps and styles of the horses are added with the precision of clockwork, and supposing that the rate of evolution has been about the same, we can approximately estimate both the periods of deposition and the intervals as follows.

PLAGIAULACIDÆ.

	Stonesfield.	Purbeck.	Laramie.	Puerco.	Cernaysian.
Number of Premolars,	?	4-3	2	2-1	1
Grooves on Premolars,	?	7-9	11-14	12-15	14
Molar Tubercles: outer;					
inner;	?	4:2	6:4	6:4	9:6

Estimating the geological intervals by dental evolution and faunal succession, there is first the great gap between the Trias of Microlestes and Dromatherium and the Jurassic of the Stonesfield slate; there is a relatively shorter interval, but still a considerable one between this and the Purbeck or Atlantosaurus beds. Then follows another long and very important interval between the Atlantosaurus beds and the Laramie (Upper Cretaceous). The gap between the Laramie and Puerco was relatively short, as indicated by the comparatively limited evolution both of the Plagiaulacids and Trituberculates. The Puerco was itself a long period in which the Plagiaulacids underwent considerable changes. Then follows an interval which it is most important to fill by future exploration, for between the Puerco and the Wahsatch the differentiation of the even and the odd-toed ungulates must have occurred. The Wahsatch proper does not mark a very extensive evolution of the forms it contains. It passes, after a slight break, into the base of the Bridger (Wind River), and then begins that splendid and almost uninterrupted succession of lake basins, terminating in the pliocene. I append a table, to be compared with that published by Marsh in his admirable address of 1877, and which exhibits the great progress of the last sixteen years.

THE SUCCESSION OF THE NORTH AMERICAN MAMMALIA.

Periods.	Horizons.	Characteristic Genera. New Types Appearing.	Types becoming Extinct.
Post or Upper PLIOCENE.	EQUUS.	*Equus*, 5 species. Elephant, E. *primigenius*. Mastodon. Llamas. Camels, *Eschatius*, *Holomeniscus*. Elk, *Alces*. *Platygonus*. Sloths, *Mylodon*, *Glyptodon*. *Ursus*.	
True PLIOCENE.	BLANCO.	*Equus*, 3 species. *Mastodon*, 3 sp. Llamas, *Pliauchenia*, *Platygonus*. Sloth, *Megalonyx*. *Felidæ*. (?) *Hyænidæ*. *Mustelidæ*.	
MIOCENE.	LOUP FORK.	*Protohippus*, *Hipparion*. *Mastodon*. Rhinoceroses, *Aphelops*, 5 species. *Canidæ*. *Felidæ*. Rodents. Edentates. Camels and Llamas, *Procamelus*, *Protolabis*. Oreodons, 3 genera. Deer, *Blastomeryx*, *Cosoryx*.	Extinction of Oreodons and hornless rhinoceroses.
Upper.	DEEP RIVER.	*Protohippus*, *Anchitherium*. First Mastodons. Oreodons, *Cyclopidius*. *Chalicotherium*. Tylopoda.	Disappearance of Chalicotherium. Extinction of Creodonts, Hyænodons.
Middle.	JOHN DAY. WHITE RIVER.	*Miohippus*. Two-horned Rhinoceros, *Diceratherium*. *Hyopotamus*. Peccaries. Oreodons. Rodents. *Canidæ*, *Felidæ*. Tylopoda.	Extinction of Elotheres and Hyopotamus
	PROTOCERAS. (Upper.)	(?) *Miohippus*. Artionyx. Appearance of tragulines, Elotheres, *Hyopotamus*, pigs and peccaries, true dogs, cats, monkeys. *Leptauchenia*. *Colodon*. *Chalicotherium*, *Aceratherium*, *Protapirus*, *Agriochœrus*. Opossums. Tylopoda, *Pœbrotherium*. Creodonts, *Hyænodon*. Rodents. Insectivores.	Extinction of Hyracodons.
		Mesohippus. Amynodon.	
Lower.	OREODON. (Middle.) TITANOTHERIUM. (Lower.)	*Mesohippus*. Titanotherium.	Extinction of Amynodons. Extinction of Titanotheres.
	UINTA.	*Epihippus*. *Amynodon*. Titanothere, *Diplacodon*. First Oreodons, *Protoreodon*. First Tylopoda, *Leptotragulus*. Tapirs. Hyracodons. Rodents. Creodonts, *Mesonyx*.	
EOCENE.			
Upper.	BRIDGER. WASHAKIE. (Upper.)	*Pachynolophus*. Appearance of Amynodons and horned Titanotheres. *Palæosyops*. *Hyrachyus*. *Triplopus*. *Achœnodon*.	Extinction of Dinocerata, of some Creodonts.
	BRIDGER. (Middle.)	*Pachynolophus*. Appearance of Insectivora, Cheiroptera, Hyracodons. *Uintatherium*. *Palæosyops*. Creodonts.	Extinction of Tillodontia.
Middle.	WIND RIVER. (Lower.)	*Hyracotherium*. *Palæosyops*. Dinocerata. *Coryphodon*. *Phenacodus*.	Extinction of Coryphodontia and Condylarthra.
	WAHSATCH.	*Hyracotherium*. Appearance of Artiodactyls, Perissodactyls: tapirs, horses, titanotheres, lophiodons. First Rodents. First Coryphodons, Lemurs and Monkeys. Creodonts, 6 families, *Palæonictis*.	Extinction of Arctocyons.
	Interval.	(*Differentiation of modern clawed and hoofed placentals.*)	
Lower.	PUERCO.	*Ptilodus*, *Neoplagiaulax*, *Polymastodon*. Ancient types of Ungulates, Carnivores and Insectivores: Amblypoda, Condylarthra, Creodonta. Tæniodonta. Tillodontia. Lemurs.	Extinction of Multituberculates (? Monotremes).
	Interval.	(*Differentiation of ancient clawed and hoofed placentals.*)	Disappearance of Marsupials.
UPPER CRETACEOUS.	LARAMIE.	*Ptilodus*. *Bolodontidæ* (Multituberculates). *Thlæodon*, Trituberculate Placentals and Marsupials. Typical dentition.	
	Interval.		
MIDDLE JURASSIC.	Atlantosaurus.	*Ctenacodon*, *Plagiaulax*, *Bolodon*, Multituberculates (? Monotremes). Triconodonts (? Marsupials). Trituberculates (? Placentals). Primitive dentition.	
	Interval.		
UPPER TRIASSIC.	Chatham Coal Beds.	*Protodonta*, *Dromotherium*, *Microconodon*, primitive Triconodonts (? Monotremes).	

The general faunal succession is marked by the sudden appearance and disappearance of certain series and rise and fall of great groups. In the Trias appears the remarkable protodont or primitive-toothed Dromotherium; we cannot determine its order at present. We still have no American fauna corresponding to the intermediate Stonesfield of England. In the Jurassic Atlantosaurus beds the three supposed representatives of the Monotremes (multituberculates), Marsupials (triconodonts), and Placentals (trituberculates), appear in equal numbers; the latter are generally characterised by the primitive dental formula. In the Laramie the Multituberculates continue in great profusion, and the Marsupials and Placentals are also numerous.

The serial succession of the Trituberculates from the Mesozoic is still an unknown chapter; we are utterly unable to connect the Dromatheriidæ of the Trias, the Triconodontidæ, Amphitheriidæ and Amblotheriidæ of the Jura with each other, or with any Cretaceous or lower tertiary mammals. The serial relations of the Multituberculates, on the other hand, have been made much clearer by the discovery of the Laramie fauna. Cope and Marsh in this country, and Smith Woodward in England, have at last broken into the long barren Cretaceous. In studying the accurate figures published by Marsh and a large collection of teeth recently made for the American Museum by Wortman and Peterson, I find that this Laramie fauna is widely separated from the Jurassic in its general evolution, and as Gaudry, Lemoine, and Cope have observed, it approaches more nearly the basal Eocene of the Puerco and the Cernaysian of France. The Multituberculates of the Laramie include the Plagiaulacidæ, represented by Ptilodus, the form with two premolars, and Meniscoëssus, with two premolars and crescentic tubercles. Meniscoëssus has a smaller fourth premolar, and is found to lead off to the huge plagiaulacid Polymastodon of the Puerco. The only other Multituberculates found are those related to Bolodon of the Jurassic and Chirox of the Puerco. The other mammals of the Laramie range from the mouse to the opossum in size; they have superior molars of the simple tritubercular type—the low cusped or bunodent molar predominating in the upper jaw, and the tuberculo-sectorial in the lower. The dental formula is mostly the typical p. 4, m. 3. Yet, judging by the angular region of the jaws, we have here both Placentals and Marsupials. Some of the teeth remind us strongly of those in the Puerco; their determination, however, is very difficult, for the jaws and teeth are almost entirely isolated. From another exposure of the Laramie, Cope has recently found the remarkable type Thlæodon—remarkable because it is a highly specialised trituberculate of typical dentition with a jaw which bears resemblance to that of the Multituberculates and of Ornithorhynchus. There is no placental angle nor strong marsupial inflection. This raises the supposition that Thlæodon may be one of the persistent trituberculate Monotremes which we are now looking for.

In the Puerco or basal Eocene, a very marked change occurs, for the American fauna loses some of its cosmopolitan character, the multituberculates or monotremes die out and the marsupials are not found at all; in fact they do not reappear in North America until the Miocene.

Ancient and Modern Placental Differentiation.

The Puerco is essentially an archaic fauna and is to be regarded as the climax of the first period of placental differentiation, a culmination of the first attempts of nature to establish insectivorous, carnivorous and herbivorous groups. These attempts began in the Cretaceous, and some of the types thus produced died out in the Puerco, some in the Wahsatch and Bridger; only a few flesh-eaters survived to the Miocene. It is most important to grasp clearly the idea of this functional radiation in all directions of this old Puerco fauna, resulting in forms like the modern insectivores, rodents, bears, dogs and cats, monkeys, sloths, bunodont and selenodont ungulates, and lophodont ungulates. This was an independent radiation of placentals, like the Australian radiation of marsupials. What was the cause of the wide-spread extinction of these types? So far as the ancient clawed types are concerned, their teeth and feet seem to be as fully adaptive in many cases as those of the later unguiculates; the hoofed types were certainly inferior in tooth evolution, for all their molars evolved on the triangular basis instead of the sexitubercular; the most sweeping defect of both the clawed and hoofed types was the apparent incapacity for brain-growth, their bodies went on developing while their brains stood still. Thus the stupid giant fauna, the Dinocerata, which rose out to this period, gave way to the small but large-brained modern types. It is noteworthy that the latest survivors of this wreck of ancient life were the large-brained Hyænodons.

Some of the least specialised spurs of this radiation appear to have survived and become the centres of the second or mid-Tertiary radiation from which our modern fauna has evolved. Yet we have not in a single case succeeded in tracing the direct connection. To sum up, we find on the North American continent evidence of the rise and decline and disappearance of monotremes and marsupials, and two great periods of placental radiation, the *ancient radiation* beginning in the mesozoic, reaching a climax in the Puerco and unknown post-Puerco, and sending its spurs into the higher tertiary, and the *modern radiation* reaching its climax in the Miocene, and sending down to us our existing types.

Another Eocene centre was lower South America, which has of late dimmed the prestige of North America in yielding strange forms of life. One theory of this Patagonian fauna is that it was an independent centre of functional radiation like the Puerco and Australian, full of adaptive parallels, but not yielding to Europe or America any of their older types. But Ameghino, to whose energetic researches we are chiefly indebted, believes that he finds a lower Eocene life zone—a sort of *south polar* centre—which supplied both America and Europe. The Puerco he believes is no older than the Santacruzian, which in turn is very much older than the Parana and Pampean formations, which Burmeister has made so well known. This yields the *Homunculus Patagonicus* which parallels Cope's Anaptomorphus in presenting a dentition as advanced in reduction as that of man. Ameghino finds here the ancestors of the Macrauchenidæ; he believes the Homolodontotheridæ are the ancestors of the Chalicotheriidæ—thus deriving a buno-selenodont from a lophodont type; the Proterotheriidæ, he believes, replace the Condylarthra and Hyracotherium in the ancestry of the horses. Similarly the Microbiotheriidæ are the stem of the creodonts and carnivores. I cannot coincide with any of these views. The Multituberculates are far older and widely different from the Abderites to which Ameghino traces their ancestry. I fully concur with the opinion of Cope, Zittel, Scott and others that this fauna is of somewhat later age, that it was directly connected with Australia and somewhat later with North America, supplying us, as has always been supposed, with our sloths. I quote from a recent address by Scott:—

"The oldest mammals from South America are those from Patagonia, which Ameghino has referred to the Eocene, but which are more probably Oligocene or Miocene. This fauna is of extreme peculiarity and isolation; it is made up chiefly of edentates, rodents and ungulates of those very aberrant types known as Litopterna and Toxodontia, which are so widely different from the hoofed mammals of the northern hemisphere; together with some primitive forms of primates, creodonts and marsupials. The marsupials are of extraordinary interest, for they comprise not only forms allied to the opossums, but also to recent Australian forms such as Thylacinus, Dasyurus and Hypsiprymnus. This is a most unexpected fact, and seems to point unmistakably to a great southern circumpolar continent."

The Puerco thus remains the most extensively known and most productive lower Eocene centre, yet we have very slender threads of positive evidence to connect its fauna with the later placental radiation.

The Creodonts of Cope occupy the same relation to the modern insectivores and carnivores that the Condylarthra do to the ungulates. The American group has been recently enriched by the discoveries of Wortman, and the literature by the careful revision of Scott. This author has divided them into eight families, placing the forms which most resemble the Insectivora in the new family, Oxyclænidæ. These families illustrate superbly the same law of functional radiation later repeated in the placental and marsupial carnivores. The Mesonyx family presents some analogies to the Thylacines. The modern bears are paralleled in the Arctocyons, with their low tubercular molars; Wortman and myself, with fresh materials, have recently added Anacodon to this family, a genus which was doubtfully regarded by Cope as an ancient ungulate. The Cats and Hyænas are imitated in the Oxyænas and Hyænodons, some of the Miocene forms of which Scott

suggests developed aquatic habits; as above noted, some of this family acquired large brains, and persisted late into the Miocene. A still more remarkable likeness to the cats is exhibited in the Palæonictis family, which, unlike the Hyænodons, forms its sectorials out of exactly the same teeth as the true cats. The first American Palæonictis was found two years ago by Wortman, and this author and myself have suggested that this may be the long-sought ancestor of the Felidæ. The Civets are anticipated in the Proviverridæ; yet both Cope and Scott, the highest authorities on this subject, believe that the dog-like Miacidæ alone formed the connecting link between the Creodonta and the true Carnivora.

The foot structure of the ancient Puerco ungulates is still only partly known. Cope has divided these animals into the Amblypoda and Condylarthra. The Amblypoda are represented in the Puerco by a large form called Pantolambda, with selenodont triangular upper molars, and possibly by Periptychus, with bunodont triangular molars. The Pantolambda molars were, as Cope has shown, converted into those of Coryphodon, the great lophodont Amblypod of the Wahsatch, by a process exactly analogous to that in which the *anterior* half of a Palæotherium molar was formed, that is, they acquired outer and anterior crests but no posterior crests. This Coryphodon molar type was still later converted into the Uintatherium type by swinging around the outer crest into a transverse crest. I have recently made a careful study of the fore and hind feet of Coryphodon, and have found that while the fore-foot was subdigitigrade like that of the elephant, the hind-foot was fully plantigrade, the entire sole resting upon the ground. The relation or connection between the Bridger Dinocerata and these earlier Amblypoda is still unknown. The Puerco Periptychus left no descendants. The other ungulates of the Puerco were the Condylarthra, the primitive Phenacodontidæ, the supposed ancestors of the Artiodactyls and Perissodactyls. Much remains to be done to clear up this question.

Thus an immense number of problems still await solution, and demand the generous co-operation of European and American specialists in the use of similar methods of research, in the prompt publication of descriptions and figures, and in the free use of museum collections. I may be pardoned for calling general attention to the service which the palæontological department of the American Museum is trying to render in the immediate publication of stratigraphical and descriptive tables of western horizons and localities.

The Factors of Evolution.

A few words in conclusion upon the impressions which a study of the rise of the mammalia gives as to the factors of organic evolution. I refer also to recent papers by Cope, Scott, and myself.

The evolution of a family like the Titanotheres presents an uninterrupted march in one direction. While apparently prosperous and attaining a great size, it was really passing into a great corral of inadaptation to the grasses which were introduced in the Middle Miocene. So with other families and lesser lines extinction came in at the end of a term of development and high specialisation. With other families no causes for extinction can be assigned, as in the lopping off of the smaller Miocene perissodactyls. The point is that a certain trend of development is taken leading to an adaptive or inadaptative final issue—but extinction or survival of the fittest seems to exert little influence *en route*.

The changes *en route* lead us to believe either in predestination—a kind of internal perfecting tendency—or in kinetogenesis. For the trend of evolution is not the happy resultant of many trials, but is heralded in structures of the same form all the world over and in age after age, by similar minute changes advancing irresistibly from inutility to utility. It is an absolutely definite and lawful progression. The infinite number of contemporary developing, degenerating, and stationary characters preclude the possibility of fortuity. There is some law introducing and regulating each of these variations, as in the variations of individual growth.

The limits of variation seem to lie partly in what I have called the "potential of evolution." As the oösperm or fertilised ovum is the potential adult, so the Eocene molar is the potential Miocene molar. We have seen that the variations of the horse and rhinoceros molars, apparently so diverse, are really uniform—is not this evidence that the perissodactyl stem had these variations *in potentia*, waiting to be called forth by certain stimuli? This capacity of similar development under certain stimuli is part of the law of mammalian evolution, but this does not decide the crucial point whether the reaction is spontaneous in the germ or inherited from the parent. I incline to the latter opinion. H. F. OSBORN.

A DYNAMICAL THEORY OF THE ELECTRIC AND LUMINIFEROUS MEDIUM.[1]

I.

IT is only at the end of the last century that the somewhat vague principle of the economy of action or effort in physical actions—which, like all other general principles in the scientific explanation of nature, is ultimately traceable to a kind of metaphysical origin—has culminated in the hands of Lagrange in his magnificent mathematical generalisation of the dynamical laws of material systems. Before the date of this concise and all-embracing formulation of the laws of dynamics there was not available any engine of sufficient power and generality to allow of a thorough and exact exploration of the properties of an ultimate medium, of which the mechanism and mode of action are almost wholly concealed from view. The precise force of Lagrange's method, in its physical application, consists in its allowing us to ignore or leave out of account altogether the details of the mechanism, whatever it is, that is in operation in the phenomena under discussion; it makes everything depend on a single analytical function representing the distribution of energy in the medium in terms of suitable co-ordinates of position and of their velocities; from the location of this energy, its subsequent play and the dynamical phenomena involved in it are all deducible by straightforward mathematical analysis.

The problem of the correlation of the physical forces is thus divisible into two parts, (i.) the determination of the analytical function which represents the distribution of energy in the primordial medium which is assumed to be the ultimate seat of all phenomena; and (ii.) the discussion of what properties may be most conveniently and simply assigned to this medium, in order to describe the play of energy in it most vividly, in terms of the stock of notions which we have derived from the observation of that part of the interaction of natural forces which presents itself directly to our senses, and is formulated under the name of natural law. It may be held that the first part really involves in itself the solution of the whole problem; that the second part is rather of the nature of illustration and explanation, by comparison of the intangible primordial medium with other dynamical systems of which we can directly observe the phenomena.

The chief representative of exact physical speculation of the second of these types has been Lord Kelvin. In the older attempts of this kind the dynamical basis of theories of the constitution of the æther consisted usually in a play of forces, acting at a distance, between ultimate elements or molecules of the medium; from this we must, however, except the speculations of Greek philosophy and the continuous vortical theories of the school of Descartes, which were of necessity purely descriptive and imaginative, not built in a connected manner on any rational foundation. It has been in particular the aim of Lord Kelvin to deduce material phenomena from the play of inertia involved in the motion of a structureless primordial fluid; if this were achieved, it would reduce the duality, rather the many-sidedness, of physical phenomena to a simple unity of scheme; it would be the ultimate conceivable simplification. The celebrated vortex theory of matter makes the indestructible material atoms consist in vortex rings in a primordial fluid medium, structureless, homogeneous, and frictionless, and makes the forces between the atoms which form the groundwork of less fundamental theories consist in the actions excited by these vortices on one another through the inertia of the fluid which is their basis—actions which are instantaneously transmitted if the fluid is supposed to be absolutely incompressible.

In case this foundation proves insufficient, there is another idea of Lord Kelvin's by which it may be supplemented. The characteristic properties of radiation, which forms so prominent an element in actual phenomena, can be explained by the

[1] A paper read before the Royal Society on December 7, 1893, by Dr. Joseph Larmor, F.R.S., Fellow of St. John's College, Cambridge.

existence of an elastic medium for its transmission at a finite, though very great, speed; such a medium renders an excellent account of all its relations, if we assume it to possess inertia and to be endowed with some elastic quality of resistance to disturbance roughly analogous to what we can observe and study in ordinary elastic solids of the relatively incompressible kind, such as indiarubber and jellies. Lord Kelvin has been the promoter and developer of a view by which the elastic forces between parts of such a medium may be to some extent got rid of as ultimate elements, and be explained by the inertia of a spinning motion of a dynamically permanent kind, which is distributed throughout its volume. If we imagine very minute rapidly-spinning fly-wheels or gyrostats spread through the medium, they will retain their motion for ever, in the absence of friction on their axles, and they will thus form a concrete dynamical illustration of a type of elasticity which arises solely from inertia; and this illustration will be of great use in realising some of the peculiarities of a related type, which I believe can be thoroughly established as the actual type of elasticity transmitting all radiations, whether luminous and thermal or electrical—for they are all one and the same—through the ultimate medium of fluid character of which the vortices constitute matter.

It has always been the great puzzle of theories of radiation how the medium which conveys it by transverse vibrations, such as we know directly only in media of the elastic-solid type, could yet be so yielding as to admit of the motion of the heavenly bodies through it absolutely without resistance. According to the view of the constitution of the æther which is developed in this paper, not only are these different properties absolutely consistent with each other, but it is, in fact, their absolute and rigorous coexistence which endows the medium with the qualities necessary for the explanation of a further very wide class of phenomena. The remark which is the key to this matter has been already thrown out by Lord Kelvin, in connection with Sir George Stokes's suggested explanation of the astronomical aberration of light. The motion of the ultimate homogeneous frictionless fluid medium, conditioned by the motion of the vortices existing in it, is, outside these vortices, of an absolutely irrotational character. Now, suppose the medium is endowed with elasticity of a purely rotational type, so that its elastic quality can be called into play only by absolute rotational *displacement* of the elements of the medium; just as motion of translation of a spinning gyrostat calls into play no reaction, while any alteration of the absolute position of its axis in space is resisted by an opposing couple. As regards the motion of the medium involved in the movements of its vortices, this rotational elasticity remains completely latent, as if it did not exist; and we can at once set down the whole theory of the vortical hydrodynamical constitution of matter as a part of the manifestations of an ultimate medium of this kind.

The explanation of the laws of physical optics advanced by Fresnel, and verified by comparison with the phenomena which was possible in several very exact ways, chiefly by himself and Brewster, was, about the year 1835, engaging the attention of several of the chief mathematicians of that time—Augustin Cauchy in France, Franz Neumann in Germany, George Green in England, and James MacCullagh in Ireland. The prevalent mode of attacking the problem was through the analogy with the propagation of elastic waves in solid bodies; and the comparison of Fresnel's laws of propagation in crystalline media with the results of the mathematical theory of the elasticity of crystalline bodies gave abundance of crucial tests for the verification, modification, or disproof of the principles assumed in these investigations.

The greatest achievement of MacCullagh is that contained in his memoir of 1839, entitled an "Essay towards a Dynamical Theory of Crystalline Reflexion and Refraction." He is in quest of a dynamical foundation for the whole scheme of optical laws, which had been notably extended and confirmed by himself already. He recognises, I think for the first time in a capital physical problem, that what is required is the discovery of the potential-energy function of Lagrange on which the action of the medium depends, and that the explanation of the form of that function is another question which can be treated separately. His memoir is subsequent to, but apparently quite independent of, that of Green, in which Green restricted the medium to a constitution like an elastic solid, laid down the general laws of such constitution for the first time, and made a magnificent failure of his attempt to explain optical phenomena on that basis. If this thing was to be done, the power, simplicity, and logical rigour of Green's analysis might have been expected to do it; and nothing further has come of the matter until the recent new departure of Lord Kelvin in his speculation as to a labile elastic-solid æther. To return to MacCullagh, he is easily able to hit off a simple form of the potential-energy function, which—on the basis of Lagrange's general dynamics, or more compactly on the basis of the law of Least Action—absolutely sweeps the whole field of optical theory so far as all phenomena are concerned in which absorption of the light does not play a prominent part. He is confident, as any one who follows him in detail must be, that he is on the right track. He tries hard to obtain a dynamical basis for his energy-function, that is, to imagine some material medium that shall serve as a model for it, and illustrate its possibility and its mode of action; he records his failure in this respect, but at the same time he protests against the limited view which would tie down the unknown and in several ways mysterious and paradoxical properties of the luminiferous medium to be the same as those of an ordinary elastic solid.

The form of MacCullagh's energy-function was derived by him very easily from the consideration of the fact that it is required of it that it shall produce, in crystalline media, plane-polarised waves propagated by displacements in the plane of the wave front. Though he seems to put his reasoning as demonstrative on this point, it has been pointed out by Sir George Stokes, and is indeed obvious at once from Green's results, that other forms of the energy-function beside MacCullagh's would satisfy this condition. But the important point as regards MacCullagh's function is that it makes the energy in the medium depend solely on the absolute rotational displacements of its elements from their equilibrium orientations, not at all on its distortion or compression, which are the quantities on which the elasticity of a solid would depend according to Green.

Starting from this conception of rotational elasticity, it can be shown that, if we neglect for the moment optical dispersion, every crystalline optical medium has three principal elastic axes, and its wave-surface is precisely that of Fresnel, while the laws of reflexion and refraction agree precisely with experiment. Further, it follows from the observed fact of transparency in combination with dispersion, that the dispersion of a wave of permanent type is properly accounted for by the addition to the equations, therefore to the energy-function, of subsidiary terms involving spacial differentiations of higher order. To preserve the medium hydrodynamically a perfect fluid, these terms also must satisfy the condition that the elasticity of the medium is thoroughly independent of compression and distortion of its elements, and wholly dependent on absolute rotation. It can be shown, I believe, that this restriction limits the terms to two kinds, one of which retains Fresnel's wave-surface unaltered, while the other modifies it in a definite manner stated without proof by MacCullagh; but the first terms depend on an interaction between the dispersive property and the wave motion itself, while the second terms involve the square of the dispersive quality. It seems clear that the second type involves only phenomena of a higher order of small quantities than we are here considering; thus an account of dispersion remains which retains Fresnel's wave-surface unaltered for each homogeneous constituent of the light, while it includes the dispersion of the optic axes in crystals both as regards their magnitudes and directions—results quite unapproached by any other theory ever entertained.

In this analysis of dispersions, all terms have been omitted which possess a unilateral character, such as would be indicated in actuality by rotatory polarisation and other like phenomena. The laws of crystalline material structures seem to prohibit the occurrence of such asymmetry as these terms would indicate, except to the very small extent evidenced by the hemihedral faces of quartz crystals. The influence of this asymmetric arrangement of the molecules on the optical medium must be very much smaller still, for the rotatory terms are in all media exceedingly minute compared with the ordinary dispersional terms. The form of these rotatory terms in the energy-function is at once definitely assigned by our condition of perfect fluidity of the medium, both for crystals and for rotational liquids such as turpentine, and this form is the one usually accepted, on MacCullagh's suggestion, as yielding a correct account of the phenomena.

When dispersional terms are included in the energy function,

our continuous analysis is not any longer applicable to the problem of reflexion; the conditions at the interface are altogether too numerous to be satisfied by the available variables. There is in fact discontinuity at the interface in the discrete molecular structure, such as could not be representable by a continuous analysis. But if we proceed by the method of rays, and assume that there is a play of surface forces which do not absorb any energy, while they adjust the dispersional part of the stress, it appears that reflexion is independent of dispersion.

The problem of the æther has been first determinedly attacked from the side of electrical phenomena by Clerk Maxwell in quite recent times; his great memoir on a "Dynamical Theory of the Electromagnetic Field" is of date 1864. It is in fact only comparatively recently that the observation of Oersted, and the discoveries and deductions of Ampère, Faraday, and Thomson had accumulated sufficient material to allow the question to be profitably attacked from this side. Even as it is, our notions of what constitute electric and magnetic phenomena are of the vaguest as compared with our ideas of what constitutes radiation, so that Maxwell's views involve difficulties, not to say contradictions, and in places present obstacles which are to be surmounted, not by logical argument or any clear representation, but by the physical intuition of a mind saturated with this aspect of the phenomena. Many of these obstacles may, I think, be removed by beginning at the other end, by explaining electric actions on the basis of a mechanical theory of radiation, instead of radiation on the basis of electric actions. The strong point of Maxwell's theory is the electromotive part, which gives an account of electric radiation and of the phenomena of electromagnetic induction in fixed conductors; and this is in keeping with the remark just made. The nature of electric displacement, of electric and magnetic forces on matter, of what Maxwell calls the electrostatic and the magnetic stress in the medium, of electrochemical phenomena, are all left obscure.

We shall plunge into the subject at once from the optical side, if we assume that dielectric polarisation consists in a strain in the æther, of the rotational character contemplated above The conditions of internal equilibrium of a medium so strained are easily worked out from MacCullagh's expression for W, its potential energy. If the vector (f, g, h) denote the curl or vorticity of the actual linear displacement of the medium, or *twice* the absolute rotation of the portion of the medium at the point considered, and the medium is supposed of crystalline quality and referred to its principal axes, so that

$$W = \tfrac{1}{2}\int (a^2f^2 + b^2g^2 + c^2h^2)\, d\tau,$$

where $d\tau$ is an element of volume, it follows easily that for internal equilibrium we must have

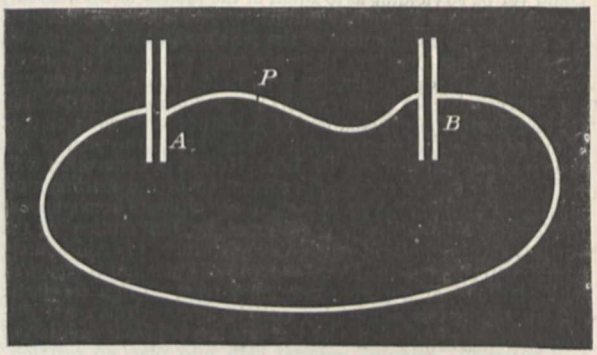
$$a^2f\,dx + b^2g\,dy + c^2h\,dz = -dV,$$

a complete differential, and that over any boundary enclosing a region devoid of elasticity the value of V must be constant. Such a boundary is the surface of a conductor; V is the electric potential in the field due to charges on the conductors; (f, g, h) is the electric displacement in the field, circuital by its very nature as a rotation, and (a^2f, b^2g, c^2h) is the electric force derived from the electric potential V. The charge on a conductor is the integral of (f, g, h) over any surface enclosing it, and cannot be altered except by opening up a channel devoid of elasticity, in the medium, between this conductor and some other one; in other words, electric discharge can take place only by rupture of the elastic quality of the æthereal medium.

At the interface between two dielectric media, taken to be crystalline as above, the condition comes out to be that the tangential electric force is continuous. When the circumstances are those of equilibrium, and therefore an electric potential may be introduced, this condition allows discontinuity in the value of the potential in crossing the interface, but demands that the amount of this discontinuity shall be the same all along the interface; these are precisely the circumstances of the observed phenomena of voltaic potential differences. The component, normal to the interface, of the electric displacement is of course always continuous, from the nature of that vector as a flux.

It may present itself as a difficulty in this theory that, as the electric displacement is the rotational displacement of the medium, its surface integral over any sheet should be equal to the line integral of the linear displacement of the medium round the edge of the sheet; therefore that for a closed sheet surrounding a conductor this integral should be null, which would involve the consequence that the electric charge on a conductor cannot be different from null. This line of argument, however, implies that the linear displacement is a perfectly continuous one, which is concomitant with and required by the electric displacement. The legitimate inference is that the electric displacement in the medium which corresponds to an actual charge cannot be set up without some kind of discontinuity or slip in the linear displacement of the medium; in other words, that a conductor cannot receive an electric charge without rupture of the surrounding medium; nor can it lose a charge once received without a similar rupture. The part of the linear displacement that remains, after this slip or rupture has been deducted from it, is of elastic origin, and must satisfy the equations of equilibrium of the medium.

We can produce in imagination a steady electric current, without introducing the complication of galvanic batteries, in the following manner, and thus examine in detail all that is involved, on the present theory, in the notion of a current. Suppose we have two charged condensers, with one pair of coatings connected by a narrow conducting channel, and the other pair connected by another such channel, as in the annexed diagram, where the dark regions are dielectric



and the white regions conducting. If we steadily move towards each other the two plates of the condenser A, a current will flow round the circuit, in the form of a conduction current in the conductors and a displacement current across the dielectric plates of the condensers. Let us suppose the thicknesses of these dielectric plates to be excessively small, so as to minimise the importance of the displacement part of the current. There is then practically no electric force and therefore no electric displacement in the surrounding dielectric field, except between the plates of the condensers and close to the conducting wires. Consider a closed surface passing between the faces of the condenser A, and intersecting the wire at a place P. A movement of the faces of this condenser alters the electric force between them, and therefore alters the electric displacement across the portion of this closed surface which lies in that part of the field; as we have seen, there is practically no displacement anywhere else in the field except at the conducting wire; therefore to preserve the law of the circuital character of displacement throughout the whole space, we must suppose that this alteration is compensated by a very intense change of displacement at the conducting wire. So long as the movement of the plates continues, as long does this flow of displacement along the wire go on; it constitutes the electric current in the wire. Now, in calculating the magnetic force in the field, which is the velocity of the æthereal medium, from the change of electric displacement, we must include in our integration the effect of this sheet of electric displacement flowing along the surface of the perfectly conducting wires, for exactly the same reason as in the correlative problem in hydrodynamics, of calculating the velocity of the fluid from the distribution of vorticity in it, Helmholtz had to consider a vortex sheet as existing over each surface across which the motion is discontinuous.

(*To be continued.*)

SCIENTIFIC SERIALS.

American Meteorological Journal, December.—The winds of the Indian Ocean, by W. M. Davis. The facts for this discussion are drawn from the "Atlas of the Indian Ocean," published by the *Deutsche Seewarte*, and the author reproduces two charts (1) for January and February, when the heat equator and the belt of low barometric pressure have advanced to about latitude 10° south in the middle of the Indian Ocean, and (2) for July and August, showing the position of the high pressure belt about 5° more northward than before, in consequence of the increased velocity of the circumpolar whirl. The most striking feature of this second chart is the extension of the south-east trade wind across the equator, as the south-west or summer monsoon. The author clearly points out the sufficiency of the rotation of the earth to influence the course of the winds, and explains the causes of the monsoons. He shows that it is not only true that continents are unessential to their development, but that they may even destroy their normal conditions.—South American meteorology, by W. H. Pickering. This paper chiefly deals with the climate of Arequipa, Peru; altitude 8,060 feet. The temperature seldom falls below 40° or rises above 75°. The winds blow with great regularity, except in the rainy season, a sea-breeze prevailing during the day, and a land-breeze for some hours before sunrise. The mean annual rainfall does not exceed four inches, while on the sea-coast rain is a great rarity; the rainy season occupies the first three months of the year; rain in the morning is practically unknown. (This and the previous paper were read before the New England Meteorological Society on October 21 last).—A South American Tornado, by W. G. Davis. This tornado occurred on November 13, 1891, and devastated the village of Arroyo Seco, near Rosario. An illustration, taken from a photograph, shows a number of heavily laden railway carriages which were upset or carried to a distance by the violence of the wind. The cause appears to have been the differences of temperature and humidity in adjacent strata of the atmosphere.—Errors of the psychrometer, by H. A. Hazen. This is a summary of a paper recently read by Mr. W. W. Midgley before the Royal Meteorological Society. The important point is that Prof. Hazen entirely confirms a statement made by Mr. F. Gaster at that meeting, that the temperature of the dry bulb thermometer is not affected by the proximity of the water cup of the wet bulb thermometer, a statement which was contrary to the general opinion of the meeting. We believe that a further confirmation of this fact will be brought forward by Mr. Gaster later on, from recent careful experiments.

L'Anthropologie, Tome iv. No. 4, July–August, 1893.—Mons. Maurice Delafosse contributes an interesting paper on a little-known tribe of fair negroes, called the *Agni*, who dwell on the Ivory Coast between the River Tanoué on the east, and the Rio San Pedro on the west. These albinos are neither so tall as some of the tribes of Senegal, nor so powerfully built as the natives of Dahomey. Their height varies from 1'65 m. to 1'80 m.; their body is well proportioned, they are quick and graceful in their movements, and they have sharp, bright eyes of unquestionable beauty. Their colour is in general of a beautiful bronze, more often light than dark. The *Agni* tattoo themselves, but the men are not circumcised. In the same number M. Eugène Mouton describes a *digito-dorsal* movement peculiar to man; and there is a paper by M. D'Acy on ornamented neolithic hammers, tomahawks, and axes.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 14, 1893.—"Note on some Changes in the Blood of the general Circulation consequent upon certain Inflammations of an acute local character," by Dr. C. S. Sherrington, F.R.S.

Linnean Society, December 21, 1893.—Prof. Stewart, President, in the chair. Gen. Sir H. Collett and Mr. H. H. Johnson were admitted, and Messrs. G. E. Greene and A. G. Tansley were elected.—Mr. P. L. Simmonds exhibited a collection of New Zealand mosses found by Mr. G. W. Simmonds while surveying in H.M.S. *Pandora*. Mr. Murray offered some remarks on the nature and value of the collection, which the owner was understood to say would be presented to the Botanical Department of the British Museum.—The President exhibited and described two curious examples of associated ants and plants, namely, *Iridomyrmex caudatus* with *Myrmecodia Beccari* and *Camponotus planatus* with *Pæudomyrma Belti*, the plant being *Acacia Hindsii*.—Mr. J. E. Harting exhibited some shells of *Planorbis corneus*, which had been found by the river-side at Weybridge, which from some unascertained cause were curiously bisected. Alluding to the piscivorous habits of the water shrew, *Sorex fodiens*, he suggested that it might be the work of this little animal. Mr. A. D. Michael thought it likely to be the result of frost, the lower half of each shell being preserved by being imbedded in or adherent to the frozen mud. Referring to a MS. letter of Dr. Stephen Hales (the author of "Vegetable Staticks," and a friend and neighbour of Gilbert White), which was exhibited by Mr. G. Murray, an excellent engraved portrait of him was exhibited by Mr. Harting, who made a few remarks upon his life and work. As this portrait was not to be found amongst the 600 engravings of "scientific worthies" lately presented to the library by the late Lord Arthur Russell, he offered it for the acceptance of the society.—On behalf of Mr. H. N. Ridley, Director of the Gardens and Forests Department, Singapore, the Secretary read a paper dealing with all the *Orchideæ* hitherto recorded from Borneo. In the discussion which followed, Mr. C. B. Clarke made some remarks on the distribution of these plants in the Indian and Indo-Malay regions, and on the way in which a knowledge of the species had been gradually acquired and extended.—On behalf of Mr. R. Spruce (whose death since the reading of this paper the Society has to deplore), Mr. A. Gepp read a paper on the *Hepaticæ* collected by Mr. W. R. Elliott in the islands of St. Vincent and Dominica, and took occasion to describe in some detail the nature and extent of Mr. Spruce's work, which he characterised as a most careful and excellent contribution to botanical science. The paper was accompanied by a series of minute and beautiful drawings.

Royal Microscopical Society, December 20, 1893.—Mr. A. D. Michael, President, in the chair.—Mr. E. M. Nelson exhibited and described a new pattern microscope specially designed for agriculturists.—Mr. Nelson also exhibited a new form of metallic chimney for microscope lamps.—On behalf of Mr. J. W. Lovibond, Mr. Nelson exhibited some new coloured screens for use with the microscope.—Mr. J. W. Gifford read a paper on a new monochromatic light screen, illustrating the subject by means of the lantern.—Mr. T. F. Smith read a paper on the resolution of *Pleurosigma angulatum*, illustrated with photomicrographs shown by the lantern.

PARIS.

Academy of Sciences. January 2.—M. de Lacaze-Duthiers in the chair.—A mechanical problem, by M. J. Bertrand.—On the equation to the derived partials occurring in the theory of the propagation of electricity, by M. Emile Picard. An application of Riemann's method to the problems considered by M. H. Poincaré at the previous meeting.—A chemical study of the nature and causes of the green colouration in oysters, by MM. Ad. Chatin and A. Muntz. The authors trace a connection between the percentages of iron contained in the coloured parts and colourless parts of the oysters and the intensity of the colouration. The branchiæ contain much more iron than the remainder of the body, and are most deeply coloured. The proportion of iron corresponding to a deep green or brown coloration is about 0·07 to 0·08 per cent. of the dried branchiæ. The mud of the oyster beds where colouration occurs contains a large proportion of sulphide of iron. Though it is insoluble in the solvents for chlorophyll and hæmatosin, the green colouring matter resembles those pigments in containing a large proportion of iron.—Graphic determination of position at sea, by MM. Louis Favé and Rollet de l'Isle.—Regulation of the compass by observations of the horizontal force, by M. Caspari.—A new isomeride of cinchonine, by MM. E. Jungfleisch and E. Léger. A base to which the name cinchonine δ has been given is obtained from hydrobromocinchonine by boiling with 85 per cent. alcohol and subsequent separation of unaltered base, apocinchonine, and cinchoniline. It forms very long prisms insoluble in water, but soluble in alcohol, benzene, chloroform, and acetone. It melts at 150°. For a 1 per cent. solution in 97 per cent. alcohol $\alpha_D = +125{\cdot}2°$. In aqueous solution +2HCl, we have $\alpha_D = +176{\cdot}9°$, and with 4HCl its rotation becomes $\alpha_D = +178{\cdot}2°$. The base and its salts decompose rapidly in air with formation of brown products less alkaline than the base itself. The salts of cinchonine

δ are generally very soluble in water, but the hydrochloride, hydrobromide, and basic oxalate form exceptions, and may be easily crystallised.—On the ophites of the Western Pyrenees, by M. P. W. Stuart-Menteath. The author controverts the supposed necessary connection between the Trias and the Ophites of this region, and shows that the presence of the latter is due to the faults of the district. He also shows that the intercalation of the ophites parallel to the surrounding beds is not an invariable case, many instances being now known of penetration of neighbouring strata, and that the granites, porphyries, and ophites of the Pyrenees are not independent of each other, but rather that the latter become important as the former die out.—On the composition of the waters of the Dranse du Chablais and the Rhone at their entrance into the Lake of Geneva, by M. A. Delebecque. The varying quantities of solid residue in the waters of these two rivers are given for various times in the year. The proportions of the substances dissolved vary, calcium sulphate being found more abundantly in winter, and the alkalies in greater proportion in summer. An approximate calculation gives for the amounts of dissolved matter carried annually into the Lake of Geneva by the Rhone and by the whole of its affluents, respectively, the figures 750,000 and 1,150,000 tons.

NEW SOUTH WALES.

Linnean Society, November 29, 1893.—Prof. David, the President, in the chair.—The following papers were read:—A Thylacine of the earlier Nototherian period in Queensland, by C. W. De Vis. The occurrence of a Thylacine, for which the name *Thylacinus rostralis* was proposed, larger than the existing species, and differing from it in other expressive features, was recorded from the Darling Downs deposits. A number of fragmentary portions of the cranium have been for some time in the Queensland Museum; but the most valuable evidence has been furnished by a recent acquisition, in the shape of the major part of the left side of an adult skull, with all the teeth except the second upper premolar in place, together with the first four cervical vertebræ.—A second note on the *Carenides*, with descriptions of new species, by T. G. Sloane. Nine new species were described, and the opportunity of reviewing the classification of the group has been taken, synoptical tables of the more important genera being furnished.—Additions to and emendations in the reference list of the land and freshwater mollusca of New Zealand, by Henry Suter. In the "Reference List" published in last year's Proceedings, a further account of several new species was promised. Descriptions, which will be fully illustrated, of these novelties have now redeemed this promise. Critical notes on various other New Zealand land mollusca accompany the descriptions. The existence in New Zealand of an undetermined species of *Gundlachia*, the young of which were formerly mistaken for an *Ancylus*, was also announced.—On the Australasian *Gundlachia*, by C. Hedley. Two Australian species, *G. Petterdi*, Johnston, and *G. Beddomei*, Petterd, were figured and described, and the dentition of the former was also elaborated. A summary was given of the whole genus, with especial reference to its discontinuous distribution, and probable path of migration.—Description of *Cæcum amputatum*, an undescribed mollusc from Port Jackson, by C. Hedley. The newest addition to the Port Jackson molluscan fauna, figured and described by the author, stands nearest to *C. auriculatum*, de Folin, from the Mediterranean. It is the first of its genus observed in extratropical Australia.—Notes on the red-crowned parrakeet (*Cyanorhamphus Cooki*) of Norfolk Island, by A. J. North. Having recently examined two specimens of this parrakeet forwarded by Dr. P. H. Metcalfe, of Norfolk Island, the author has found it to be specifically distinct from *C. novæ-zealandiæ*, as maintained by Count Salvadori, in whose views as to the incorrectness of the habitat assigned to *G. Cooki* by Gray, and the necessity of regarding *C. Rayneri* as a synonym of *C. Cooki* he therefore concurs.—Fourth contribution to a knowledge of the geographical distribution of Australian batrachia, with description of a new cystignathoid frog, by J. J. Fletcher. The collections recorded are mainly from the Lower Clarence and the Northern Tableland of N.S.W.; and a new species of *Crinia*—with vomerine teeth, the tympanum indistinct, the throat very dark, the belly maculate and granulate, a light vertebral line—from Jervis Bay, proposed to be called *C. Haswelli*, was described.—Description of a new Australian *Acacia*, by J. H. Maiden and R. T. Baker. A well-defined and somewhat remarkable species from Murrumbo, near the Goulburn River, N.S.W., was described. It bears some superficial resemblance to *A. decurrens*, var. *normalis*, but the length of the leaflets, the fewness of the glands, the pinnæ, and the flowers in the heads (six or eight only), are the principal distinctive differences upon which the specific rank is based. This species commemorates Baron Ferd. von Mueller, the eminent botanist, to whom we are indebted for the classical "Iconography of Australian Acacias."

NETHERLANDS.

Zoological Society, November 25, 1893.—M. Hubrecht in the chair.—M. Hubrecht contributed a paper on the development of the Shrew (*Sorex vulgaris*), and especially on its placentation. The placenta is an embryonal organ; the part which the tissue of the mother plays in its formation is considerably smaller than has been supposed.—M. Seydel exhibited models of embryonary skulls of Anguis and Lacerta, made of wax after the method of Born.—M. Bolsius dealt with the anatomy especially of the generative organs of *Branchiobdella parasita*.—M. Vosmaer treated on the so-called membrane of Sollas, in sponges of the genus Sycon.—M. Hoek described a hermaphroditical ray (*Rajaclavata*). A specimen of a length of 44 centimetres (without the tail) was in possession of a single pterygopodium (the left one) only. On dissecting it was found to be furnished with a complete set of female reproductive organs (ovaries, oviducts, oviductal glands, uteri), and at the left side with a well-developed testis containing mature spermatozoa.

BOOKS, PAMPHLET, and SERIALS RECEIVED.

BOOKS.—Electromagnetic Theory: O. Heaviside, Vol. i. (*Electrician* Publishing Company).—Eau Sous Pression: F. Bloch (Paris, Gauthier-Villars).—Annuario publicado pelo Observatorio do Rio de Janeiro, 1893 (Rio de Janeiro).—The Crinoidea of Gotland, Part 1—The *Crinoidea Inadunata*: F. A. Bather (Stockholm, Norstedt).—Index-Catalogue of the Library of the Surgeon-General's Office, U.S. Army, Vol. xiv. (Washington).—Results of Rain, River, and Evaporation Observations made in N.S.W. during 1892: H. C. Russell (Sydney).

PAMPHLET.—Report of the Meteorological Council to the Royal Society for the year ending March 31, 1893 (Eyre and Spottiswoode).

SERIALS.—Geographical Journal, January (Stanford).—Natural Science, January (Macmillan).—Handbuch der Palæontologie Erste Abthg. iv. Band, 3 Liefg. (Williams and Norgate).—Observatory, January (Taylor and Francis).—Bulletin of the New York Mathematical Society, December (New York, Macmillan).—Revue Générale des Sciences, No. 24 (Paris).—Annals of Scottish Natural History, January (Edinburgh, Douglas).—American Journal of Science, January (New Haven).—Journal of the Royal Statistical Society, December (Stanford).—The Physical Society of London, Proceedings, Vol. xii. Part 3 (Taylor and Francis).—Contributions from the Botanical Laboratory of the University of Pennsylvania, Vol. i. No. 2 (Philadelphia).—Medical Magazine, January (Southwood).

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