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THE OLD AND THE NEW KINETIC THEORY.

The Kinetic Theory of Gases. By Dr. Oskar Emil Meyer. Translated from the Second Revised Edition by Robert E. Baynes, M.A. Pp. xvi + 472. (London: Longmans, Green and Co., 1899.)

A Treatise on the Kinetic Theory of Gases. By S. H. Burbury, M.A., F.R.S. Pp. vi + 158. (Cambridge: At the University Press, 1899.)

IT is difficult for a reader at the present time to imagine himself back in the seventies before the first edition of Meyer's "Kinetische Gastheorie" appeared. After the outlines of the kinetic theory of gases had been sketched out by Clausius and Maxwell, much was needed to bring the theory into closer accord with the requirements alike of the mathematician and of the experimentalist. The back numbers of the *Wiener Sitzungsberichte* testify to the keen interest taken in the subject at the period to which we are alluding, and in connection with diffusion and other allied phenomena mainly depending on the free paths of the molecules of gases, a prominent place must be given to the writings of Oskar Emil Meyer. It was Meyer, for example, who taught us that in the diffusion of two gases whose molecules have unequal powers of penetrating into one another, a counter-current must set in to compensate for the differences of pressure which would otherwise be produced by the transference of molecules in the direction of the more penetrable gas—a theory which has met with wide acceptance.

Mr. Baynes, in preparing the English version of a new edition of Meyer's treatise, has given English readers a book calculated to meet the wants of a large and varied class of persons interested in the kinetic theory. Mathematicians will naturally turn their attention to the 112 pages of "Mathematical Appendices," and will there obtain an introduction to theories for the further development of which they will probably pass on to the writings of Boltzmann, Tait, Watson, Natanson and others; while the removal of this mathematical matter to a separate section renders the book specially suited to students of physics and chemistry who are interested with experimental conclusions rather than with abstract reasoning. It was for such readers that Meyer's first edition was written in 1877, and there can be no doubt that the book, presenting, as it does, the subject in the aspect of a physical reality and not as a mere collection of formulæ which may or may not accord with results of experiments, has done much to popularise the kinetic theory of gases, and thus indirectly to help to make its name at least familiar even to elementary pass-degree candidates. Now that we have an English edition students can have no excuse for not carrying their knowledge of the subject rather further; for a better introductory treatise could hardly be written, and there is little in Meyer's treatment that could present difficulties even to the veriest beginner. After an introductory chapter on the foundations of the theory, the relations between pressure and energy are dealt with very fully. "Maxwell's Law" is illustrated by a curve showing the distribution of speed, a diagram showing shots on a target distributed according to the error-law, and a statistical table showing the relative proportions of molecules whose speeds lie between different limits, reminding one of the statistical reports required by the Civil Service examiners. The two last illustrations well exhibit the fact that the probability of a molecule having its *speed* zero is infinitely small, and that there is a certain speed whose frequency is a maximum, notwithstanding that the most probable value of the *velocity component* in any direction is zero. In the chapter on "Ideal and actual gases," we have an account of Van der Waals' and allied hypotheses; while under the heading "Molecular and atomic energy" the specific heat ratios of gases and their dependence on the number of degrees of freedom of a molecule for heat-motions are discussed.

The second part deals with molecular free paths and the phenomena depending on them. It contains an exhaustive account of all that has been done in explaining viscosity, diffusion, and heat-conduction by the kinetic theory, the part on viscosity alone extending over seventy-six pages. The third part, which is much shorter than the two preceding ones, deals with "direct properties of molecules," including determinations of the size, number, and speed of molecules and the magnitudes of intermolecular forces. This concludes the physical portion of the book. In the mathematical appendices, the calculations are in many cases based both on Clausius' hypothesis of equal speeds, and also on Maxwell's distribution, and while the former method is at the present day of purely academic interest, its inclusion may be serviceable to beginners. Mr. Baynes has supplied an index besides adding to the already copious references to original memoirs, which are an important feature of the treatise. While a number of new theories have been inserted, and on the other hand many recent developments have been excluded, the author has perhaps wisely made the general scope and plan of the book the same as in the first edition. As he remarks in his preface,

"with the present limitation to the old range it has cost very much trouble and very much time to work up the literature of the subject, which has grown mightily in these more than twenty years."

While Prof. Meyer and Mr. Baynes are contented to accept "Maxwell's Law" as a working hypothesis, Mr. Burbury has taken up the far more difficult task of working out the distribution of a system of molecules under conditions to which the ordinary proofs of the Boltzmann-Maxwell distribution are inapplicable, viz. when finite intermolecular forces exist, or when the volume of the molecules is not infinitely small compared with the total volume of the gas. The appearance during recent years of several papers from Mr. Burbury's pen has acquainted us with the general character of his labours, which involve practically the foundation of a new kinetic theory, and we are glad to read the general conclusions in the form of a handy treatise. In investigating the distribution of molecular co-ordinates and momenta, Burbury points out that we may take two different fundamental assumptions for our starting-point, namely, "Condition A," that the chance of any molecule having velocity components within given limits *is* independent of the

distribution of co-ordinates and velocities of the other molecules ; or "Condition B," that the chance of a given molecule having at any instant assigned velocities *is not* independent of the positions and velocities of all the other molecules at the instant. Condition A readily leads to the Boltzmann-Maxwell distribution, but Burbury finds that the assumption of Condition B (which is, of course, of wider application than Condition A) leads to a new law of distribution, according to which the chance of a system of molecules having their velocity components within the limits of the multiple differential of these components is

$$Ce^{-h\Omega}du_1dv_1dw_1 \ . \ . \ . \ du_ndv_ndw_n,$$

where

$$\Omega = \Sigma m(u_r^2+v_r^2+w_r^2) + \Sigma\Sigma b_{rs}(u_ru_s+v_rv_s+w_rw_s).$$

The b coefficients are functions of the distance between the molecules, which become inappreciable except when this distance is very small. When the b coefficients are negative, their meaning is that two near molecules are more likely to be moving in the same than in opposite directions, and the motions of the molecules are then said to be *correlated;* while in the opposite case of b_{rs} positive the motions are said to be *contrarelated.* It should be observed that $u_ru_s+v_rv_s+w_rw_s$ is equal to $q_rq_s\cos e$ where q_rq_s are the speeds, e the angle between their directions.

The view that the ultimate distribution differs from the Boltzmann-Maxwell distribution being at variance with the results of "Boltzmann's Minimum Theorem," Burbury carefully examines the proof given by Boltzmann, and concludes that "what the H theorem proves then is this, that the distribution of velocities expressed by the equation $Ff' = Ff$ is the only distribution which can be permanent consistent with the existence, and the continued existence of Condition A or its equivalent." In the motion obtained by reversing the velocities Condition A is not satisfied. Burbury considers that in this proof Boltzmann's assumption that the motion is "molecular ungeordnet" is equivalent to "Condition A." He remarks :—

"Let us endeavour to construct synthetically a system which shall without doubt be molecular ungeordnet. The molecules being distinguished by numbers, I ask (say) Dr. Watson to assign velocities to them according to any law he pleases. Then I, in complete ignorance of those assigned velocities, scatter the molecules at haphazard through space, and they shall start from the positions which I so give them with the velocities so assigned them by Dr. Watson. That is *prima facie* a molecular ungeordnet system ; in fact, it is as near an approach to chaos as is possible in an imperfect world."

Burbury next proves that if the intermolecular forces, are finite, Condition A cannot exist, and $uu'+vv'+ww$ has an average finite value, a function of r which is positive if the forces are repulsive. This proof involves the assumption that $\overline{uu'}$ is zero in the absence of intermolecular forces, and we are told :

"Strictly, n the number of molecules in the system being finite and the centre of inertia at rest, it must be negative, but it may be neglected when n is great."

This is rather a difficult assumption to accept without further explanation. The proof that "correlation" must exist when the molecules are equal elastic spheres is much more laborious. In the chapter on "General theory of the stationary motion," it is shown that "Maxwell's law of partition of energy" does not necessarily hold except when Condition A is satisfied. This is as it should be ; otherwise the heat given to a polyatomic gas would be divided equally between all the atoms of all the molecules, instead of being divided, as Boltzmann teaches us, mainly between the translatory and rotatory motions of the molecules, which are the only motions to which Condition A is applicable.

Under the title "On molecules as carriers," we have a short account of Boltzmann's simple method of treating diffusion and allied phenomena, based on the latter's "Vorlesungen über Gastheorie." We hope that the general mathematical reasoning on which Burbury's theory of correlation rests is not to be gauged by his method of investigating the mean free path on p. 115, in which he says : "Let $1-\pi c^2N\lambda/\omega = \phi(\lambda) = \phi$," and a few lines later infers that $\phi = e^{-k\lambda}$ where $k = \pi c^2N/\omega$, and $k\lambda$ is finite.

The chapter on "Thermodynamical relations" well brings out the fact that while Burbury's new distribution, like the conventional one, fulfills the condition that dQ has an integrating divisor, the usual symbol for which (in this country) is the first letter of the word "Temperature," but little progress has so far been made in explaining the fundamental properties of temperature by molecular motions. The properties of irreversible thermodynamics are nowhere more manifest than in the friction, heat conduction, and imperfect elasticity of solid bodies whose molecules are not only correlated, but appear inseparably interlocked. Yet hardly any headway has been made in getting the equation of energy-equilibrium between two bodies into a form analogous to that expressing equality of temperature, except under highly specialised assumptions as to the law of distribution of energy, which prevent the conclusions from being applied to any but attenuated gases. Every attempt to advance in the desired direction has hitherto led to hopeless mathematical difficulties.

A discussion on the merits of Burbury's new method of analysis would be out of place in the present review. His theory represents the outcome of much thinking, and is not to be disposed of hastily. It boldly faces the question of correlation, and thus brings us one step nearer towards explaining the properties of dense assemblages of molecules. It has the remarkable property that the character of the motion changes completely when the expression Q ceases to be essentially positive, by the vanishing of the determinant of the coefficients of Q or of one of its leading minors ; and we know that the state of a gas also suddenly changes by liquefaction. Seeing, however, that it is necessary to regard actual molecules, not as spheres or material points, but rather as non-spherical rigid bodies, it still remains for Burbury to tackle the far more difficult question of the distribution of translatory and rotatory motions of unsymmetrical or axially symmetrical molecules when correlation exists. And we have a kind of vague feeling that probability considerations and finite molecular forces which are functions of the distances and positions of the molecules are bringing us not much nearer the desired goal of explaining temperature. Indeed, the question of deducing the

laws of irreversible heat-phenomena from probability considerations becomes more and more difficult the more it is studied. But physicists have given us another source of irreversibility, of which the kinetic theorist has hitherto made little use. The equation

$$\frac{d^2(r\phi)}{dt^2} = a^2 \frac{d^2(r\phi)}{dr^2}$$

representing propagation of spherical waves is satisfied mathematically by $r\phi = F(at+r) + f(at-r)$; but the physicist has to make the axiom that waves always radiate *from*, and never converge *to* a source of disturbance, and hence, that the second term alone exists in nature. Seeing that the molecules on our earth derive so much of their heat-energy from the sun, which energy is (if we may use the expression) transported across some ninety million miles of ether by equations of this type, it is surely desirable that some working hypothesis should be formulated for the conversion of radiant energy into energy of heat motion, and a kinetic theory involving such a hypothesis would explain irreversibility as a natural consequence of the simple axiom involved in the suppression of $F(at+r)$.

We trust that neither Mr. Burbury nor Prof. Boltzmann will construe any of these remarks into expressions of criticism on the points of difference between their conclusions, and we hope that ere long both these writers will enlighten us further on the questions at issue. The writer of the present review has (doubtless in common with many others) spent a considerable amount of time in trying to attack that tantalising question of temperature from a kinetic standpoint coupled with probability considerations, or even deducing the law of molecular distribution from the temperature-property; but every attempt leads to an impenetrable wall built of dense assemblages of molecules which cannot be assumed to follow the Boltzmann-Maxwell distribution, and which seem to say to the mathematician, "Thus far shalt thou go, but no further."

G. H. BRYAN.

THE ZOOLOGY OF THE INDIAN SEAS.

A Descriptive Catalogue of the Indian Deep-Sea Fishes in the Indian Museum. Pp. iii+212 and viii.

An Account of the Deep-Sea Brachyura. Being Systematic Reports upon the Materials collected by the Royal Indian Marine Survey Ship "Investigator," 1874-1899. By A. Alcock, M.B. Pp. ii+85. (Calcutta: Printed by the Trustees of the Indian Museum, 1899.)

THE Catalogue of Deep-Sea Fishes is a monumental work, since it completes the description in full of a large number of species already listed in the author's papers, now well known, and illustrated in the "Illustrations of the Zoology of the *Investigator*" which he inaugurated in 1892, and which, thanks to the skill of his native artists, is likely to become classic.

The fishes dealt with number 169 species, the Anacanthini and Physostomi being, as might be expected, in the majority, and but two of them Plectognathi. 126 of these stand to the record of the *Investigator* alone, and 43 only appear identical with species found elsewhere; 23 are said to be common to the Indian seas and the Atlantic, and a special feature is the occurrence of a Trachinoid fish (*a Bembrops*) originally found in Japan. Dr. Gunther, as is pointed out, has already familiarised us with the idea of a former open connection between the Mediterranean and Japanese seas; and, discussing this fish and certain related forms, the author dismissing the "comfortable formula" "similarity of conditions," is led to the conclusion that "a considerable part of the fish-fauna of the Oriental region originated from, and to a certain extent is a remnant of, the fauna of the Tertiary Mediterranean of Suess—of a Mediterranean that extended from the present Gulf of Mexico, through the present Mediterranean basin, far into the eastern hemisphere."

The chief novelty of the present work is a chart compiled from Koken's "Vorwelt und ihre Entwickelungsgeschichte" with the object of rendering clear the bearings of the above conclusion. The present coast-lines and those supposed to have existed during the Tertiary period are indicated in dissimilar contours, and the presumed area of the Inland Sea is rendered appropriately clear. In the construction of this chart the author has sought the advice by Mr. T. H. Holland, formerly of the Royal College of Science, London, and that gentleman's splendid work on the Geological Survey of India amply justifies the choice.

The fresh-water fishes (mainly Ostariophyseæ and Cichlidæ) come in for consideration. The occurrence of a Symbranchid species common in Tropical America and Australia, of Cyprinodonts known from Tropical Africa and America, are duly emphasised, while the author's records concerning the Cichlidæ (Chromides) have an especial value now that our knowledge of this remarkable group is being revolutionised by our distinguished English Ichthyologist, Boulenger.

It is praise sufficient to remark that this grand monograph in no way falls short of its predecessors we have so recently reviewed (see NATURE, vol. lx. p. 459), and that it will remain for generations a standard work of reference.

The report on the Brachyura is serial with those on the Madreporaria and Ophiuroidea, and, like the former, is prefaced by an account of the history of the expedition and of its association with the Indian Museum. It completes the work of the expedition on the crabs, and as regarding descriptions of new species it is supplemental to a series of earlier papers by the author, his former associate and predecessor in office, the late Prof. Wood-Mason, and his present colleague, Dr. A. R. L. Anderson, extending over a period of more than twenty years. The present volume deals with 53 species and 38 genera, with two exceptions from depths of over 100 fathoms; and of these 21 genera and 5 species are known from other seas. Interest centres in the discovery of affinities between the fauna of the Indian and Atlantic deep-sea areas, which the author is disposed to interpret as indicative of a former open connection between the two, for which he has already argued in reporting upon the Madreporaria. Bathymetrically one species only (an *Ethusa*) was obtained at a depth exceeding 1000 fathoms, 3 (*Ethusa*, 2 sp. and a *Hypsophrys*) between 800 and 1000 fathoms, 3 between 500 and 800, and 18 between 400 and 500, while of the majority obtained at depths of from 100 to 400 fathoms

many also occur in shallower water. A supposed *Doclea* stands alone as a true shallow-water species captured at the hundred fathom line.

The list reveals a predominance of Oxystomid and Oxyrhynchid forms, and the careful diagnoses which comprise the bulk of the report are illustrated by four exquisite plates, drawn by the native artists who so fully distinguished themselves in the delineation of the corals. For accuracy and beauty of execution they would be difficult to surpass, and it affords us great pleasure to add that in the collotyping process employed by Messrs. Taylor and Francis, who have reproduced these drawings, nothing has apparently been depreciated or lost. The result is an entirely new departure in English art work, full of promise for the future. In dealing with the higher Crustacea Dr. Alcock is on his strongest ground, for his "Materials for a Carcinological Fauna" is already an established work of cyclopædic importance. The result of the present undertaking is a triumph for those concerned, the *tout ensemble* a memorable one, and as a final comment upon it we can only add that Dr. Alcock has incurred yet another contribution to the debt of gratitude due to him by zoologists at large.

ANTIQUITIES OF CENTRAL AMERICA.

A Glimpse at Guatemala and Some Notes on the Ancient Monuments of Central America. By Anne Carey Maudslay and Alfred Percival Maudslay. With Maps, Plans, Photographs, and other Illustrations. Pp. xvii + 289. (London: Murray, 1899.)

FOR the last two decades the name of Mr. A. P. Maudslay has been the most conspicuous of those associated with archæological work in Central America. No other explorer, not even excepting Mr. Stephens himself, has covered so much ground and obtained such valuable results in this wide field of research. Since 1881 he has spent many years amid the ruined cities of Guatemala, Yucatan, and Honduras, has studied the monuments in minute detail, taken innumerable drawings and castings of carvings and inscriptions, drawn elaborate ground plans of palaces and temples from which the rank vegetable growths had first to be cleared. On the main and special features of these crumbling remains he has published several copious monographs in the *Geographical Journal* and elsewhere, and is now giving to the world the results of his seven expeditions in the *Biologia Centrali-Americana*, of which eight parts, with no less than 200 plates, have already been issued.

When, therefore, this sumptuous volume was announced, specialists and other close students of American antiquities looked forward to a great banquet spread out with a view to their particular tastes and expectations. In this respect they will certainly be somewhat disappointed, while the general public will be all the more charmed with a book of travels which is written in a fascinating style, and in which the note of living human interest is stronger than that of a vanished past. The book is exactly what it professes to be—a brightly written account of a final visit paid in 1894 to the scene of his long and fruitful labours, the main object being to take a general look round, and give in a small compass a rough idea of the vast amount of work which has been accomplished, and will be permanently recorded in the more costly and less accessible volumes of the *Biologia*.

During this last survey Mr. Maudslay was accompanied by his wife; and the arrangement by which the lighter and more descriptive sections were entrusted to her skilful pen has been attended with the happiest results. Besides some very searching "glimpses" at the country, its scenery, vegetable and animal life, and present inhabitants, special visits were paid to Coban, Rabinal, Copan, Quiregua, Ixkun, Chichen Itza, Palenque, and Tikál, and some further archæological work carried out at several of these places. Special chapters written by Mr. Maudslay are devoted to such work, while Mrs. Maudslay takes charge of the incidents of travel, household matters, the surroundings, attitude of the natives, and so forth. Some of her pictures are extremely graphic, as when she enters sympathetically into the bird life, and tells us how

"we shared our dining room with the birds, who came in flocks to feed on the ficus and other fruit-bearing trees, and we were never weary of watching them at play amongst the branches overhead. At first the parrots and parroquets vastly outnumbered all the others, and appeared to have formed a settlement in the tree above our tent. These parrots were a boisterous family, who woke at dawn, and began screaming and chattering whilst they performed round the branches all those gymnastic feats which I have thought were only devised in captivity to vary the monotony of cage-life. But the parroquets, who lived in the same tree, appeared to be quiet little creatures, who nestled near to one another, whispering and cooing gently, until some sudden impulse would seize both parties, and they would dash off in the air, flashing circles of gold and red and green as the sun caught the glint of their plumage, and then return as suddenly to the shelter of the trees to chatter loudly over their exploits."

While all this is going on, Mr. Maudslay is busy amid the neighbouring ruins on the banks of the Copan, which he had first surveyed in 1881, and studied more carefully in 1885. Here was revealed the fine ornamental doorway of a temple, and here the important discovery was made that nearly all the truncated pyramidal mounds had been crowned by temples, thus bringing these monuments, like those of Chichen Itza, Uxmal, and so many others in Yucatan, in line with Cholula, Teotihuacan, Papantla, and the one or two other extant Mexican *teocalli*. The genesis of all is the same—mounds raised above the remains of departed chiefs, and terminating, not with a point as in Egypt, but with a platform on which to perform sacrificial rites and build the teocalli ("God's House"), when in due course the great chief joined the Clympians. But were these structures built by the same race, and, if so, by whom? In a chapter on "Conclusions" Mr. Maudslay discusses this vexed question in connection with the obscure relations of Toltecs, Nahuas, and Mayas, and infers that the Toltecs were not of Aztec (Nahua) but of Maya stock. He, however, speaks with uncertain voice, and still doubts whether the stream of migration set from Mexico southwards or from Central America northwards. But the problem may now be regarded as solved in favour of the first assumption; and if Mr. Maudslay hesitates, it is only

because he overlooks one of the factors essential to its solution. The cradle of the Maya race is not Yucatan, which they appear to have been the first to occupy as an already civilised people (Mercer). They brought their civilisation with them from the Anahuac tableland, which they had reached from the Atlantic slopes (Tamaulipas, Vera Cruz), where the original stock still survives. Here the widely-diffused Huaxtec nation speaks, not a dialect or a later form, but an archaic type of Maya speech. Here also they had attained a high degree of culture in remote times, as attested by the wonderful truncated pyramid of Papantla, which, although described by Humboldt, appears to be again forgotten. Though of small size, Papantla must rank as the most wonderful structure of the kind in the New World, being built, not of adobe, like Teotihuacan, Cholula, and those farther south, but of huge porphyry blocks covered with glyphs and carvings of snakes and alligators, and exquisitely polished, like the monoliths of Tiahuanaco on the shores of Lake Titicaca. The pyramid is disposed in receding terraces, and the platform on which the sacrifices were offered is approached by a broad flight of steps. Papantla is consequently a type of these structures, which, like the dolmens and menhirs of the Afro-European men of the New Stone Age, may now be followed along the Maya line of migrations through Cholula to Tula (Tollan), and thence by the western (Pacific) route to their new homes in Central America. What drove them south? Natural expansion or invasion? Clearly the latter, else they must have held their ground in the great centres of their culture on the plateau—Teotihuacan and Tula—where the ruins are not of Nahua, but of Maya type. The Nahuas, probably distant kinsmen of the North American Shoshones, came later, and swept in successive waves of barbarism over the tableland, clearing out the cultured Huaxtecs (northern Mayas), and destroying their great city of Tollan, whence came their name, "Toltecs." The last wave was that of the Aztecs, who, after settling in the Valley of Mexico (Tenochtitlan) and developing a certain culture under Huaxtec influences, also spread southwards, following the same Pacific route, and ranging as far as Guatemala, Salvador and Nicaragua (Pipils and Niquirans). Now everything may be explained. Safely entrenched on the Chiapas-Guatemalan plateau, the early Mayas continued to develop their "Toltec" culture, partly assimilating the Quichés and other rude aborigines, all of whom now speak languages of Maya stock, and at last passing at the apogee of their civilisation into the hitherto unoccupied limestone peninsula of Mayapan (Yucatan). Here they were still later (not long before the discovery) followed by the conquering Aztecs, whence the traces of distinctive Nahua art, such as

"those curious mural paintings recently found by Dr. Gann in British Honduras, on the eastern limit of the Maya area, paintings essentially Nahua in style, yet accompanied by a legend in Maya hieroglyphs" (p. 252).

Mr. Maudslay also devotes a chapter to this Maya script, which he rightly distinguishes from the Aztec, while "doubtful if more than a mere trace of phoneticism has as yet been established" (p. 254). A very full and lucid account is given of the ingenious method by which Mr. J. T. Goodman has with some measure of success attempted to solve the riddle of the Maya Calendric system. But, strange to say, no reference is made to Mr. Cyrus Thomas's more extended and perhaps more fruitful labours in this difficult field of palæographic research. In his "Day Symbols of the Maya Year" (*16th Ann. Report Bureau Eth.*, p. 205), Mr. Thomas seems at all events to prove that the Maya Script had passed from the pictographic through the ideographic to an initial stage of a true phonetic system. As in the Egyptian hieroglyphs, all the processes are no doubt intermingled, while several of the symbols must be read phonetically as syllables if not as letters. The system would thus appear to have reached the rebus stage, in which some of the characters are to be taken as pictograms, some as ideograms, and some as syllables irrespective of their pictorial value.

On the broader question of the independent evolution of American culture, Mr. Maudslay takes what may now perhaps be called the orthodox view.

"It is, indeed, possible that accidental drifts from Asia may occasionally have influenced American culture, but such drifts across a great ocean must have been few and far between. If the population of America came originally from the Asiatic Continent, such an original migration must have taken place so early in the history of the human race that it antedated the use of bronze, iron, or domestic animals in the land from which the migrants came" (p. 272).

In other words, whatever the American aborigines owe to the Old World dates from the Stone Ages, as the expression is commonly understood, all else has been locally developed independently of any extraneous influences.

The volume, it is almost needless to say, is superbly illustrated with over a hundred photogravures, chromo-lithographs, ground-plans and etchings, besides a large scale-map of all the Central American lands (Guatemala, Yucatan, Chiapas, Honduras and neighbouring districts) in which ruined cities have been discovered. There is also a sufficiently copious index, and the volume is altogether handsomely equipped. A. H. KEANE.

OUR BOOK SHELF.

Das Geschlecht der Pflanzen. Von R. J. Camerarius. Pp. xiii + 78. (Leipzig: Engelmann, 1899).

IT seems difficult to believe that scarcely two centuries have elapsed since botanists first began to recognise the most elementary fact in the sexual propagation of plants, namely, the function of the pollen as the male fertilising agent. Yet such is the fact. The letter of Camerarius to Valentin, "De sexu plantarum," published in 1694, marks an epoch in the history of botany. Up to that time a knowledge of the processes which must precede the production of a fertile seed had remained *in statu quo ante* since the time of Theophrastus, the pupil of Aristotle; nor was any further substantial advance made before the writings of Kölreuter and Sprengel, seventy and one hundred years later.

The services of Camerarius to botanical science have been amply acknowledged by the historians of botany, especially by Sachs in his "Geschichte der Botanik" (see Garnsey's translation, pp. 385-90), who speaks of his letter to Valentin as being "often mentioned, but apparently little read"; but now for the first time we have a translation of it in any modern language, and the little book is a valuable addition to the botanist's library.

Camerarius' method was thoroughly Darwinian. His conclusions were based entirely on most careful personal observations; and all objections to his explanations were impartially noted and carefully considered. It was largely from the phenomena exhibited by unisexual, and especially by dicœcious, plants that Camerarius drew the conclusion admirably summed up in his own words (Garnsey's translation): "In the vegetable kingdom no production of seeds . . . takes place unless the anthers have prepared beforehand the young plant contained in the seed. It appears, therefore, justifiable to give these 'apices' a nobler name, and to ascribe to them the significance of male sexual organs, since they are the receptacles in which the seed itself, that is, the powder which is the most subtle part of the plant, is secreted and collected, to be afterwards supplied from them. It is equally evident that the ovary with its style represents the female sexual organ of the plant."

The thanks of all botanists are due to the publishers and to Prof. Möbius, who has prepared the translation, for this somewhat tardy tribute to the work of a great investigator. But few of his contemporaries recognised its merits; our own fellow-countryman, Ray, perhaps, more than any other. A. W. B.

Journals and Papers of Chauncy Maples, D.D., F.R.G.S., late Bishop of Likoma, Lake Nyasa. Edited by Ellen Maples. Pp. 278. (London: Longmans and Co., 1899.)

THE presence of an attractive and educated personality for some twenty years in equatorial savage Africa is explained by the fact that Chauncy Maples was an Oxford member of the Universities' Mission to Central Africa. The first sixty pages contain the journal of his journey through the Meto country, an abstract of which was given before the Royal Geographical Society in 1882. The last paper is the unfinished one of a series in the *Nyasa News*, the first paper printed on the lake, and started by him in 1893. It ends with pathetic abruptness by an unanswered question: he was drowned in the lake as he was writing it. The papers form a sequel to the "Life," which has already been noticed in NATURE; they manifest a sincere, human and kindly perception of the aims of scientific investigation. There is much chatty natural history throughout these papers. One of them compares Anyanja with Melanesian as depicted in Dr. Codrington's "Studies." But perhaps the most valuable contribution is the paper read in 1891 before the Oxford Graduates' Missionary Association on the power of the conscience, the sense of the moral law, and the idea of God amongst certain tribes in East Africa. Anthropologists will, in fact, find the first-hand impressions of a cultured English gentleman after years of residence. J. F. H.

Leçons de Chimie Physique. Par J. H. van't Hoff. Ouvrage traduit de l'allemand par M. Corvisy. Deuxième partie: La Statique Chimique. Pp. 162. (Paris: Hermann, 1899.)

WE have now before us a French translation of the second part of van't Hoff's admirable lectures on physical and theoretical chemistry. Attention was drawn in the notice of the first part (NATURE, vol. lix. p. 458, 1899) to the somewhat unusual division of the subject. There, under the title of chemical dynamics, equilibrium and velocity of reaction were dealt with on the basis of thermodynamics and the law of mass action; here, under the title of chemical statics, we have a methodical and systematic treatment of molecular chemistry. In Part I. mathematical methods were of necessity adopted; in Part II. the methods are more purely chemical, and will appeal in especial to the organic chemist.

After a short review of the nature of the atomic and molecular theories, the author proceeds to discuss molecular weight and polymerism in a section which occupies half the present volume. Avogadro's law and the molecular weights of gases naturally receive first attention, and are briefly disposed of. Then, at much greater length, come the methods for the determination of molecular weights in solution, the classification being in accordance with the thermodynamic cycles involved in their deduction from the gas-laws for dilute solutions. Molecular complexity and the anomalies encountered with isomorphous mixtures and electrolytic solutions are next discussed, the section concluding with an account of the work done on solid solutions. The author clearly discriminates between crystalline and amorphous solutions, and it is interesting in this connection to find that he is of opinion that palladium-hydrogen probably contains the hydrogen in the state of single atoms, and that the retention of dyes by fibres is not, strictly speaking, a case of solid solution, but of surface action, like the absorption of various substances by charcoal.

The second section of the book is on molecular structure, and includes subjects of such general chemical interest as the determination of constitution and configuration, isomerism, tautomerism and racemism. As one might expect from the chief founder of stereochemistry, the treatment of this section is masterly, both in its brevity and in its clearness.

The third and concluding section deals with molecular grouping and polymorphism. In it are discussed the laws regulating the transformation of polymorphous substances, the theories of crystallographic structure, and the orientation of molecules in the crystal.

To those who teach and to those who study advanced chemistry the book is indispensable. J. W.

Gli Agrumi. By Prof. Antonio Aloi. Pp. xi + 238. (Milano: Ulrico Hoepli, 1900.)

THIS book, which is one of a series of manuals, deals with the cultivation of oranges, lemons, and other species of the genus *Citrus*.

Among the subjects treated of are the soil and climate suitable to the growth of these plants, manuring, grafting, spacing of the trees, pruning, irrigation, parasites, and maladies. One may mention as deserving special notice the tables given to elucidate the scientific treatment of manuring, which are calculated from chemical analyses of fruit, leaves, &c., combined with the computed production of the latter per plant. With regard to maladies, different remedies, which have been suggested and tried, are described. The concluding chapter contains calculations as to the expenses and profits connected with the cultivation of the plants in question. The book is small, nicely got-up, and contains five coloured plates illustrating different diseases, and twenty-two wood-cuts. It should be very useful to those concerned in the cultivation of oranges and other plants; many points in it, moreover, are of interest to the general botanist.

Star-Land. By Sir Robert S. Ball, F.R.S. New and revised edition. Pp. viii + 388. (London: Cassell and Co., Ltd., 1899.)

THE new edition of this popular work on astronomy, based on lectures addressed to a juvenile audience, calls for little remark. A few additional illustrations have been introduced, but we are astonished to find that some of the original diagrams have not been amended. Fig. 17, for example, shows a large sun-spot far outside the sun-spot zone; and Fig. 23 shows the altitude of the sun at noon on the shortest day much too great in comparison with the position indicated for the longest day. If the author's name were unknown, diagrams like these would certainly suggest a want of personal acquaintance with astronomical phenomena.

Brain in Relation to Mind. By J. Sanderson Christison, M.D. Pp. 142. (Chicago: Dr. Christison, 1899.)

"COMPARATIVELY few physicians and fewer laymen," says Dr. Christison, "have a satisfactory view of the relationship of brain to mind," and we are afraid that Dr. Christison is not among the minority. When the writer of a book that purports to be a serious work on psychology commits himself to such statements as that "the use of means to a given end implies the pre-existence of a specific potentiality having a plan in the abstract, for only the pre-existing can be the cause of a necessity"; and that "the evolution idea . . . is absolutely incompatible with law and order," it would be out of place to deal with him in a serious review.

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.*]

Is New Zealand a Zoological Region?

As some weeks must elapse before Mr. Farquhar is able to reply to the questions asked (p. 273) by my good friend Mr. Wallace, I would urge your readers to bear in mind that no particular sanctity should be attached to the word "Region." Such a sanctity was once ascribed to the word "Species," and to no one living more than Mr. Wallace are we indebted for the removal of the misconception therein involved. Properly used both are very good words, and it would not be easy to get on without them; but to each may be ascribed a virtue which it does not rightly possess. In the case of New Zealand I would meanwhile refer to the expression of Prof. Huxley's views in the *Proceedings* of the Zoological Society for 1868, which so far as I know have never been refuted. ALFRED NEWTON.

Cambridge, January 20.

Compensation in Weather.

As our climate does not, in a long series of years, undergo permanent change, we are accustomed, in a time of extreme cold, wetness, or other quality of weather, to expect, in a vague way, that we shall have, ere long, a variation in the opposite direction, equalising matters. Is it possible to attain greater definiteness in such expectation, and, utilising the principle of compensation, to forecast, in a measure, the character of an approaching season?

I propose to inquire what sort of relation subsists between the cold of a given winter and that of the thirty winters preceding.

We may conveniently measure the cold of winter seasons by the total number of frost days from September to May. (For brevity, we shall here designate each winter season by the year in which it *ends*; 1842, *e.g.* meaning 1841–42.)

Let us, then, begin by adding the numbers of frost days in the thirty winters 1842 to 1871, 1843 to 1872, and so on. We thus get a series of twenty-nine numbers, varying from 1593 to 1717, with an average of 1653.

The following table may now be considered:—

Groups of 30 winters containing, of frost days,			Average number of frost days in winter following.
(1) Under 1610	...	3 cases	... 68·0
(2) 1610–1629	...	6 ,,	... 66·2
(3) 1630–1649	...	5 ,,	... 60·4
(4) 1650–1669	...	6 ,,	... 44·0
(5) 1670–1689	...	2 ,,	... 51·0
(6) 1690 or more	...	6 ,,	... 42·0

Thus, in general, the larger the number of frost days in the 30-winter groups, the smaller, on an average, is the number in the winter following. A reversal occurs at No. 5. (But there are only two cases.)

This is, perhaps, very much what we should expect on the principle of compensation.

Analysing further, we must bear in mind that the data considered are not very numerous, and beware of building too much on a slender foundation. The remarks here offered are rather by way of suggesting a method which might perhaps be found practically helpful, if fuller data were found to point in the same direction. We may, then, note these three facts:—

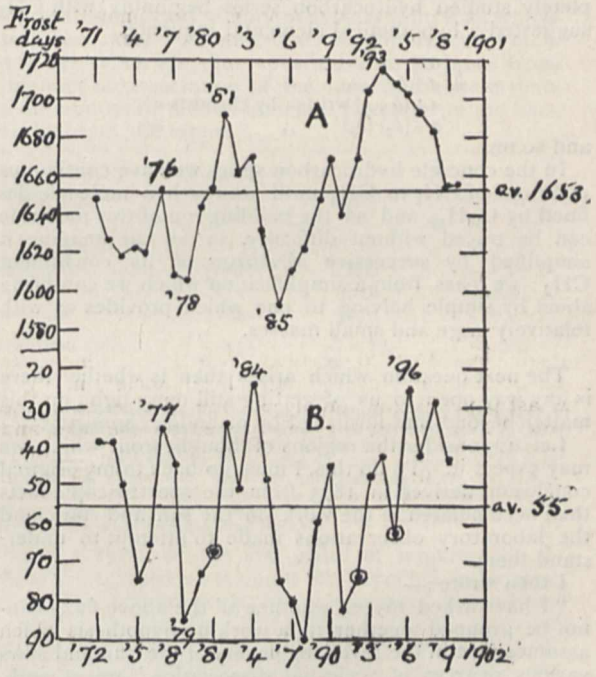
(1) The six mildest winters (since 1871) were each preceded by a 30-year group having *more* than the average of frost days.

(2) The six *coldest* winters were each preceded by a 30 year group having *less* than the average of frost days.

(3) Of fifteen 30-year groups with excessive cold (*i.e.* over the average), as many as *twelve* were followed by mild winters, and only *three* (*i.e.* one-fifth) by severe winters.

Applying the same method to frost days in the first half of each year, it might be shown that out of *twelve* 30-year groups with excessive cold, *ten* were followed by mild first halves, and only *two* by severe first halves.

Reverting to the former case (total winter seasons), the diagram represents, in curve A, the total frost days in 30-winter groups ending 1871, 1872, &c. Below is an inverted curve, the first point of which indicates the number of frost days in winter 1872, the second in winter 1873, and so on. (The time scale below, it will be seen, is shifted one year to the left.)



A. Curve of frost-days in 30 winters ending 1871, 1872, &c.
B. Curve of frost-days in winters 1872, 1873, &c. (inverted).

A certain correspondence may be traced between these curves. And taking the dots above the average line in A, it will be seen, how, except in three cases, marked by a small circle (in B), each corresponds with a mild winter in B, a fact already noted.

There is a curious lag in part of the second curve. We find two conspicuous wave-crests in A, viz. in 1881 and 1893, and the highest points (*i.e.* lowest values) in B are in 1884 and 1896. Further, the lowest point in A is in 1885; the lowest in B in 1888. An interval of three years in each case. It might be worth while to observe whether this is repeated to any extent in the future course of these curves.

Now the last thirty winter seasons (ending 1899) have a total of 1657 frost days, and if we allowed ourselves to speculate as to the quantity of frost in the current winter season (1900) we might at least perhaps fairly anticipate, or might have anticipated, that this would not turn out an extremely severe winter, and that the chances are rather against its being extremely mild either. But the point I would emphasise is that, with copious material, useful hints might possibly be obtained as to the limits within which the character of a coming season (or other portion of time), as to heat or other quality would probably occur. To this end, I may remark, some might find a diagram of dots helpful, in which, taking the case of winters, the abscissæ and ordinates are used for the 30-winter groups, and the following winters respectively, a dot being placed at each crossing point of the lines from the two scales. ALEX. B. MACDOWALL.

THE METHODS OF INORGANIC EVOLUTION.[1]

II.

I HAVE already said that I think most chemists would consider that the formation of larger masses by polymerisation is more probable than by the coming together of dissimilar atoms; but if we consider chemical compounds, certainly the analogy is all in favour of the latter view if the principle of continuity be taken into account, for we are ignorant of the point at which one evolutionary process resigns in favour of another. The present separation of compound from simple bodies is, indeed, simply a measure of our ignorance arising from the feebleness of our laboratory resources in relation to the temperature required to produce more and more simplifications.

I discussed this question in my "Chemistry of the Sun"[2] in 1887, and showed that the analogy of the completely studied hydrocarbon series beginning with CH_2 suggested a hypothetical elemental sequence.

a b
$a+b$
$a+(b+b)$ written by chemists ab_2
$a+(b_2)$ (b_2) ,, ,, ab_4

and so on.

In the concrete hydrocarbon series we have continuous additions of CH_2 to CH_4 until we reach a molecule defined by $C_{16}H_{34}$, and as the building up of this molecule can be traced without difficulty, so we can imagine it simplified by successive *sheddings* of its constituent CH_2; we pass from a simplification which we can bring about by simple halving to one which provides us with relatively large and small masses.

The next question which arises then is whether there is any way open to us of getting still more light on this matter beyond that furnished by orthodox chemistry.

Let us consider the regions of thought from which we may expect it. To do this, I must go back to my original conclusion derived in 1873 from the spectroscopic facts then accumulated in the work on the sun and stars, and the laboratory observations made to attempt to understand them.

I then wrote:—

"I have asked myself whether all the above facts cannot be grouped together in a working hypothesis which assumes that in the reversing layers of the sun and stars various degrees of 'celestial dissociation' are at work, which dissociation prevents the coming together of the atoms which, at the temperature of the earth and at all artificial temperatures yet attained here, compose the metals, the metalloids and compounds."[3]

With the progress of science the idea of "atoms" has considerably changed, and this change of view enables us to study the question of dissociation in a more rigid way than was previously possible.

Formerly "atoms" were regarded as merely chemically different from element to element; the recent investigations have introduced a new conception. It is now no longer chemically different matter merely, but matter, whether chemically different or not, *carrying an electric charge*. In the first work along this new line physicists, in order to grapple with the phenomena of electrolysis and solutions, imagined sub-molecules or sub-atoms carrying an electric charge in an electrolyte from the anode to the kathode; this was called an ion (Gr. a goer). This conception has been more recently used to explain those movements of particles of matter which produce light, and therefore spectral lines. The sub-particle, this *ion*, with its electric charge e and its mass m, is supposed to move in an elliptic orbit under the attraction of a centre. At first the theory supposed the ions to be electrified particles, but a recent extension considers them to be complex dynamical systems the motions of which are registered by spectral phenomena.

It will be gathered from what I have already said relating to the various questions connected with the study of "series" of spectral lines how the idea of "complex dynamical systems" is also demanded to explain the phenomena presented by them.

Thus I have shown it to be probable that the hydrogen atom which the chemist weighs may be built up of hundreds of the things, call them what you will, a few of which in the hottest stars produce the vibrations which we take as demonstrating the existence of hydrogen in the celestial spaces.

Both these lines of modern evidence tend to justify the view that the different spectra are not produced by different material, but by different conditionings of the same material.

These different conditionings may refer either to the electric charge or to the mass of the ion, or of the molecule round which the ion circulates. The units of matter present in the ion or in the central molecule may vary in number, or their arrangement may vary.

Imagine a series of substances "chemically" different, the intrinsic difference of which really consists merely of their being built up of *different numbers of units*, from A the simplest to Z the most complex. When Z is simplified by heat, its complex system of centre of force and ion with their electric charges will undergo changes which we may expect to result in the formation of less complex systems doubtless built on a like pattern, and therefore capable of producing spectra; hence we are bound to see the spectra of some of the intermediate forms which, when they are stable and go about in company, it may well be that physicists have already recognised. These we may call B or C, or R or S, or X or Y, as representatives of various complexities.

The more complex the form experimented on and the higher the temperature employed in the laboratory, the more spectral lines indicating different chemical "elements" in intermediate stages may we see.

I say in the laboratory because in the stars the result will be different. There, in consequence of the long continued action of heat and the shielding of the reversing layer from the effects of lower temperature, we may only see at the highest temperature the spectra of the forms A and near A. We now know what these are.

To take another case, let us assume that the electric charges or arrangement as well as the number of the units of matter may vary. Under these conditions, when we dissociate Z, not all, but only some, of possible intermediate forms may be expected to afford spectral evidence. Say, to take an example, those in the vertical columns of Mendeléef's table, and I am led to make this suggestion because Kayser has shown that in "series" the duplicity or triplicity of lines is associated with the position of the elements producing them in these columns. A concrete case would be afforded by contrasting the behaviour of sodium and cæsium, representing relatively simple and complex substances. We might observe the lines of sodium when cæsium is dissociated; we should not expect to see the lines of cæsium when sodium is dissociated.

The two cases taken it is possible may illustrate the difference between related and not related groups of "elements."

The apparently constant appearance of representative lines of the spectrum of one substance of a group in that of the other member of the same group may be thus explained, although it has generally been attributed to the presence of impurities, as in the case of all common long lines seen in spectra; and this in spite of the pro-

[1] Continued from p. 131. [2] P. 263 *et seq.*
[3] Bakerian Lecture, 1873 (*Phil. Trans.*, clxiv. Part 2, p. 491).

test that if the purest specimens known (I have worked on beads of Stas' silver which had never been touched) were so impure, some of the decimals used to express their atomic weight might be well spared. But it is not a question of apparent impurities only.

It is possible that some of the gases of lower atomic weight which exist in the hottest stars may be represented by A in opposition to heavy metals represented by Z, the existence of which is known in the cooler stars only.

The giving off of gases from metals when high tension electricity is employed is well known. This has been explained by assuming them to be "furnace gases," that is, gases "occluded" by the metals during their reduction. But this does not seem to be a sufficient explanation, for the same gases are given off by meteorites. We now see why something like this may happen if there is any foundation for the modern conception of the structure of the "atom"; and do not these facts explain the chemistry of the hottest stars?

It is too early yet to attempt to discuss the effects of the electric charge in this connection, but it must be pointed out that so soon as the ions, however associated their units may be, which are supposed always to have an electric charge upon them, are subjected to the action of a voltaic or induced current, the spectral phenomena observed when they are heated are liable to great changes in some cases, and especially when high atomic weights are in question. Doubtless we have here a field of research which will ultimately supply us with the most precious knowledge. I have already shown that with the gases, such as hydrogen and oxygen, heat alone gives rise to no spectral phenomena, while in the case of such metals as sodium heat is so effective in its dissociating power that the subsequent application of electricity produces no further change.

We have, in fact, to consider that the effects produced on different substances under the same conditions may be different, and that the stars carry us further than our laboratories; that is there are stages of spectral change within and beyond our experimental powers revealing a *shedding* of ions at different temperatures.

Dr. Preston's Researches.

Quite recently the study of magnetic perturbations of spectral lines has brought a fresh array of evidence on this question.

It has now been proved that spectral phenomena are different when the light source under examination is subjected to the action of a strong magnetic field which, among other things, causes a precessional movement of the orbits of the ions to which I have already referred.

In order to consider the bearing of this, let us deal with the spectrum of zinc which contains triplets. It has been shown that denoting these in ascending order of refrangibility by A_1, B_1, C_1, A_2, B_2, C_2, &c., the lines A_1, A_2, &c., show the same magnetic effect in character, and have the same value of e/m. The lines B_1, B_2, B_3, &c., and C_1, C_2, C_3, &c., form other series, and possess a common value for the quantity e/m in each case.

Dr. Preston, one of the most successful workers in this new field, states:—

"The value of e/m for the A series differs from that possessed by the B series, or the C series, and this leads us to infer that the atom of zinc is built up of ions which differ from each other in the value of the quantity e/m, that each of these different ions is effective in producing a certain series of lines in the spectrum of the metal."

But this is by no means all that is to be learned from Dr. Preston's researches. He writes:—

"When we examine the spectrum of cadmium or of magnesium—that is, when we examine the spectra of other metals of the same chemical group—we find that not only are the spectra homologous, not only do the lines group themselves in similar groups, but we find in addition that the corresponding lines of the different spectra are similarly affected by the magnetic field. And further, not only is the character of the magnetic effect the same for the corresponding lines of the different metals of the same chemical group, but the actual magnitude of the resolution as measured by the quantity e/m is the same for the corresponding series of lines in the different spectra. This is illustrated in the following table, and leads us to believe, or at least to suspect, that the ion which produces the lines A_1, A_2, A_3, &c., in the spectrum of zinc is the same as that which produces the corresponding series A_1, A_2, A_3, &c., in cadmium, and the same for the corresponding sets in the other metals of this chemical group. In other words, we are led to suspect that, not only is the atom a complex composed of an association of different ions, but that the atoms of those substances which lie in the same chemical group are perhaps built up from the same kind of ions, or at least from ions which possess the same e/m, and that the differences which exist in the materials thus constituted arise more from the manner of association of the ions in the atom than from differences in the fundamental character of the ions which build up the atoms."

Magnetic effect.	Nonets or complex triplets.	Sextets.	Triplets.
Cadmium ... $\lambda =$	5086	4800	4678
Zinc ... ... $\lambda =$	4811	4722	4680
Magnesium ... $\lambda =$	5184	5173	5167
Precessional spin ...	$\frac{e}{m} = 55$	$\frac{e}{m} = 87$	$\frac{e}{m} = 100$

[This table shows the effect for the three lines which forms the first natural triplet in the spectrum of cadmium compared with the corresponding lines in the spectrum of zinc and magnesium. It will be seen that the corresponding lines in the different spectra suffer the same magnetic effect both in character and magnitude. Thus the corresponding lines 4800, 4722, 5173 are each resolved into sextets, and the rate at which the ionic orbit is caused to precess is the same for each (denoted by $e/m=87$ in the table). Similarly for the other corresponding lines.]

This is a result of the first order of importance. I previously discussed what might be expected to happen if the complex system giving the spectrum of an element were *broken up*, and showed that if less complex systems of the same pattern—that is, consisting of centre of force and ion with its electric charge—were thus produced, these systems would be just as capable of giving spectra as the one the breaking up of which produced them. We should get new ions free to move and vibrate, and new spectra which may reveal the constituents, that is, the manner in which the complex system breaks up. But Dr. Preston goes further than this. He shows that the same ion associated with different centres of force gives us lines at different wave-lengths. That a certain ion which in the spectrum of magnesium gives rise to b is also present in zinc and cadmium, though there is no trace of b in their spectra.

Now, if the views held by those who have worked along any of these lines be confirmed, we shall be compelled not only to give up polymerisation as the only cause of greater complexity of the molecules of the elements, but to acknowledge a great strengthening of the view that all chemical atoms have a common basis, and build new mental images on this basis. I now pass from the spectroscopic evidence to work in a new field.

Prof. J. J. Thomson's Researches.

I have before referred to the fact that science now has to consider masses much smaller than the atom of hydrogen. This we owe not only to a discussion of the phenomena of series but also to some recent researches of Prof. J. J. Thomson, made in connection with his work on the kathode rays.

Since the kathode rays produce luminous effects their path can be traced, hence it is known that they are deflected in a magnetic field. This deflection depends upon the mass of each particle and the electric charge it carries, that is, upon their ratio, m/e. This ratio Prof. J. J. Thomson finds to be about one-seven-hundredth of the corresponding value for the hydrogen ion in ordinary electrolysis.

At the same time it has been found by Prof. J. J. Thomson and Mr. Townsend that the electric charge e is the same for kathode rays and a hydrogen ion. The m/e in fact may be regarded as independent of the nature of the gas. Since then the m/e of the hydrogen ion is 700 times greater than in the case of kathode particles, the m, the smallest mass whose existence Prof. J. J. Thomson has glimpsed, can only be about one-seven-hundredth of the hydrogen ion.

Prof. J. J. Thomson writes :—[1]

"The explanation which seems to me to account in the most simple and straightforward manner for the facts is founded on a view of the constitution of the chemical elements which has been favourably entertained by many chemists ; this view is that the atoms of the different chemical elements are different aggregations of atoms of the same kind. In the form in which this hypothesis was enunciated by Prout, the atoms of the different elements were hydrogen atoms ; in this precise form the hypothesis is not tenable, but if we substitute for hydrogen some unknown primordial substance X, there is nothing known which is inconsistent with this hypothesis, which is one that has been recently supported by Sir Norman Lockyer for reasons derived from the study of the stellar spectra."

* * * * *

"Thus on this view we have in the kathode rays matter in a new state, a state in which the subdivision of matter is carried very much further than in the ordinary gaseous state : a state in which all matter—that is, matter derived from different sources such as hydrogen, oxygen, &c.—is of one and the same kind, this matter being the substance from which all the chemical elements are built up.

* * * * *

"The smallness of the value m/e is, I think, due to the largeness of e as well as the smallness of m. There seems to me to be some evidence that the charges carried by the corpuscles in the atom are large compared with those carried by the ions of an electrolyte."

Thus the whole question of dissociation has been advanced because while on the chemical view we have to deal with intrinsically different kinds of matter from element to element, on the view of Prof. J. J. Thomson m is a constant for every element, reminding one of Rydberg's general formula for series in which N_0 is practically a constant for every element, although Rydberg acknowledges slight variations which may be due to errors of observation.

Prof. J. J. Thomson is thus led to the following view of the differences in construction of a simple "atom" and a compound "molecule" :

"In the molecule of HCl, for example, I picture the components of the hydrogen atoms as held together by a great number of tubes of electrostatic force ; the components of the chlorine atom are similarly held together, while only one stray tube binds the hydrogen atom to the chlorine atom."

Dr. Preston's results on the magnetic perturbation of lines, to which I have already referred, leads him to the same general conclusions as those arrived at by Prof. J. J. Thomson in favour of the view of dissociation. He says :—

"It may be, indeed, that all ions are fundamentally the same, and that differences in the value of e/m, or in the character of the vibrations emitted by them, or in the spectral lines produced by them, may really arise from the manner in which they are associated together in building up the atom."

And again :—

"We have, I think, reasonable hope that the time is fast approaching when intimate relations, if not identities, will be seen to exist between forms of matter which have heretofore been considered as quite distinct. Important spectroscopic information pointing in this same direction has been gleaned through a long series of observations by Sir Norman Lockyer on the spectra of the fixed stars, and on the different spectra yielded by the same substance at different temperatures. These observations lend some support to the idea, so long entertained merely as a speculation, that all the various kinds of matter, all the various so-called chemical elements, may be built up in some way of the same fundamental substance."

The Three Ways of Inorganic Evolution.

At the present time, then, we have before us three suggested ways of inorganic evolution.

Taking the chemical view, this may depend on

(1) Polymerisation, or the combination of similar chemical molecules, or

(2) The combination of dissimilar chemical molecules.

In the new physical view all this is changed into

(3) The gradual building up of physical complexes from similar particles associated with the presence of electricity.

In this last conception we have the material world, up to the highest complex, built up of the same matter under the same laws ; as in spectrum analysis there is no special abrupt change between the phenomena presented by the simple and compound bodies of the chemist, so also in the new view there is no break in the order of material evolution from end to end.

Certainly the new view seems competent to throw light on many facts which lacked explanation on the old one, by whatever method of evolution the higher complexes were assumed to be brought about. Because on the ionic theory we can imagine several first forms, so that the question of *descent* comes later with the introduction of more complex systems. These various first forms bring about the possibility of evolution along several parallel lines, as well as of the possibility of an infinite number of intercrossings. In this connection we must not forget that the constituents of the reversing layer of Bellatrix and of protoplasm are nearly identical, while the particular forms of matter of which they are composed make so little show in the sun.

The analogy before suggested between the earth and moon, and the central congeries of material units and the ion revolving round it, suggests that the ion may be the more constant in its structure, and that it is to a large extent to the varying mass charge representing the centre of force that spectral changes are due. It may be that the subordinate "series" indicate that very small variations of complexity are possible, as well as greater ones.

In the light of this analogy, the ions visible in the simple spectra of the hottest stars are those associated with the smallest centres of force. These are, so far as we know at present, hydrogen, helium, asterium, oxygen and nitrogen among the gases ; carbon and silicium, and calcium, magnesium and sodium among the metals, in the forms we study by their spectra at the highest temperatures we can employ in our laboratories.

As the stars cool larger aggregates of material units in the centres of force round which these ions revolve become possible, and hence the complexity of the spectrum of Uranium and of the sun, representing a cool star, are both explained by the same process, the various stages of which can be reproduced in the reverse direction by various degrees of dissociation.

NORMAN LOCKYER.

[1] *Phil. Mag.*, vol. xliv. p. 311, October 1897.

THE LONDON UNIVERSITY ELECTION.

SINCE the appearance of last week's NATURE, the course which we ventured to foreshadow in reference to the impending election has fortunately been found practicable. It was announced on the 17th inst. that a committee of graduates unconnected with either of the two party organisations had invited Sir Michael Foster, K.C.B., to contest the seat, and that he had consented to be put in nomination. This fact ought to reassure all those graduates who desired to see the University do itself honour by selecting a fitting successor to Sir John Lubbock. And a passage in Dr. Benson's letter to the *Times* led to a general belief that at least one of the candidates now before the constituency would be willing to retire before a man of really distinguished position and qualifications. Unfortunately, however, it appears that up to the present time neither of them has evinced any readiness to withdraw his personal pretensions.

The only reason assigned by their friends appears to us wholly untenable. They have both presented themselves to the constituency as the special friends of the country graduates. Both of them objected to the report of the Cowper Commission on the ground that in some way or other—not very clearly defined—the interests of the general body of graduates, particularly those who lived at a distance from the metropolis, would be sacrificed to the wishes and the influence of a body of professors connected with the London Colleges. Each of them has secured the adhesion of some of the members of Convocation by conveying the impression that the development of the University, on one of its two sides, as an institution capable of aiding and controlling the higher education of the metropolis, and of bringing the more eminent of the London teachers into vital connection with its governing body, would entail some possible injustice to the older graduates, and cause the value of their degrees to be lowered.

There is not, and never has been, any justification for a fear of this kind. The status of the existing graduates has not been affected, or indeed threatened, by any of the proposals of the Commission or by the subsequent legislation. Nothing has been done to lower the character of the degrees possessed by the present members of Convocation, or to put in peril any of their privileges.

Nor is the principle of external graduation in the future in any way at stake in this election. That principle has been emphatically endorsed in the recommendations of the Royal Commission, constantly restated and enforced in all the resolutions of the Senate as well as of Convocation, and finally safeguarded by the explicit terms of the Act of Parliament. It is difficult to see how a champion of that principle is needed in the House of Commons, or what a member of that House could now do to give to that principle increased strength and permanence.

The fact is that when the statutes of the reconstituted University shall have been framed and have received the Royal Assent, all the controversy which has been rife within the University itself will be at an end. And it is to be observed that in formulating those statutes Sir M. Foster and Mr. Busk have taken an equal share of responsibility, so that both are presumably well equipped with knowledge of the internal constitution of the University and its wants in the future. The domestic politics of the University, even were they far more important than they are, ought not to be uppermost in the consideration of any graduate who has in view the true reputation and influence of his University, and the purpose which ought to be served by the choice of a University member. Ordinary constituencies may be safely trusted to send to Parliament a sufficient number of members who will promise to obey the party Whip, and to look well after local affairs. But the claims of a University to representation rest on other grounds. Such a constituency is bound first to have regard to the national interests in respect to the promotion of learning and science, and to the exposition, when occasion requires, of the views of learned men. A University constituency fails wholly in its duty to the nation if it cannot enrich Parliament by sending to it men of recognised authority and large intellectual influence.

Much stress has been laid upon the voting at recent senatorial elections, as if it furnished a test of the views of the electorate. But any inference thus drawn is wholly unwarranted, and might be seriously misleading. The cases are not parallel. When the graduates are called on to select one of their own number to become one of the Senate, it is reasonable that what are called domestic politics should occupy a large share of attention. For the Senate is the executive body of the University, and is solely concerned with its internal affairs. But when the graduates are invited to choose a *burgess* in Parliament, their responsibility is of a wholly different character, and their choice should be determined by higher, larger, and more permanent considerations. What are the needs of the community in regard to national education, how far it is desirable or possible for the State to supply these needs, what should be the action of the Government in relation to matters in which the interests of science, literature, art, the higher professions, or the encouragement of research are concerned;—all these are grave questions requiring for their solution men of affairs, and of practical knowledge, and of acquaintance with other Universities than their own. And from this point of view it must be evident that the claims of Sir Michael Foster, who, in addition to his other distinctions, is known as a former student and professor in University College, and a graduate of London chosen by Cambridge to become one of its foremost professors, far outweigh the claims of any competitor whose name is before the constituency.

It is important that those members of the University who take this view of the public duty which is cast upon them at the present election will lose no time in making known their willingness to serve on Sir Michael Foster's committee. Pending the publication of a formal address, which is expected to appear immediately, graduates would do well to send in their names to Sir John F. Rotton, 3, The Boltons, S.W.

AMERICAN HIGHER TECHNICAL EDUCATION.

IN dealing with the question of American higher education, we must not lose sight of the fact (due to various causes) that any system of education in a young country like America would probably require certain modifications if adopted in an old world country. The latter would probably be steeped in traditions, many of which are doubtless of great value, yet unsuitable to the requirements of a new country. Americans have derived their fundamental principles of educational methods from us, and have formed them into a system adapted to their special needs. The question which naturally arises, however, after studying the American system, is whether in a modified form it might prove a success in our own country.

In order to more thoroughly understand this system, it will be necessary to explain their methods of working. It is intended to deal only with the course of training undertaken by an engineering student in America, as the same thoroughness characterises the work done by those qualifying for other professions.

The system is nearly the same in all the important American colleges. The student enters at an average age of about nineteen, after passing a severe entrance

examination in English, mathematics, and one foreign language. There is at present a strong tendency to raise the standard required for entrance, in order to exclude all but well-trained students.

The length of the course is four years, and comprises mathematics, physics, chemistry, English, French, German, and engineering. The course in pure science is extensive and thorough; chemistry and physics both have fairly extensive laboratory work, while in mathematics the course includes differential and integral calculus, with a small amount of differential equations.

The bulk of the work in pure science is finished by the end of the first two years, the last two years being devoted mainly to professional subjects. The manual training classes or workshops are considered to be one of the most important parts of the engineering course. The reason for the great attention given to practical work is due to the entire absence in America of anything similar to our premium pupilage system. There is no desire to reach the level of hand skill of a good mechanic, the intention being to teach correct methods of using tools, and to show how work should be done.

There are usually four shops through which the student passes in rotation. In the wood shop the course consists of a series of exercises illustrating the use of tools and forms of simple joints; this is followed by a course in wood turning, which naturally leads on to pattern making; fairly complicated patterns are made, such as a spoked wheel, plug cock with the necessary core-box. In the foundry, moulding is taught both in sand and loam, and cores are made and baked by the students; castings are not made from every mould, but only sufficiently often to show the correct methods of working. In the smith's shop there are also a set of exercises on forging, and sometimes the student has to make and harden a complete set of lathe tools for his own use in the turning shop. In the fitting shop the student passes through a course in chipping, filing, scraping, and then goes on to the machine tools, such as the lathe, the milling machine, planer, and shaping machine. The exercises have all been carefully thought out, so that they form a progressive series, each illustrating some principle.

Summer workshop classes of about one month are common, when the students devote their whole time to practical work. During this period the students often undertake to make either the whole of a machine or to finish a previous year's work. At Sibley College they have built wholly in their shops a 60 horse-power triple expansion marine type engine, which is used for experimental purposes; the finish of this engine was quite equal to any ordinary engine, and it was said to run quite as well as any other steam plant.

The shops as a rule are large and well equipped; for instance, there are thirty engine lathes besides other machine tools at Sibley College. One of the most surprising features of their manual training is the amount of hand skill which the student acquires in his comparatively short course; this is, by the Americans, attributed to the fact that their shops are entirely devoted to teaching, and that therefore they can advance the men more rapidly than is possible in a commercial establishment. The question as to whether handicraft is a suitable subject to be taught in a university is too large to be discussed here; but as regards America there can be no doubt of its value, and it is found in every really important engineering course throughout the United States and Canada.

The experimental work in the engineering laboratories is very similar to our own, but everything is on a much larger scale; there are often quite a number of testing machines and experimental engines, each intended to emphasise some special point.

At Sibley College and at Boston there are special engines for teaching valve setting, both for slide valves and Corliss gear. They have at Sibley College a small ammonia refrigerating plant arranged for experiments on the action of inverse heat engines.

MacGill University has a very fine hydraulic plant for studying the laws of flow of water through orifices, pipes and over weirs. The electrical laboratories are large and well equipped; in the dynamo room there are machines of all types for illustrating continuous, alternating and polyphase currents. The supply of testing instruments, such as ammeters, voltmeters, wattmeters, appeared to be on a generous scale.

At several institutions there are full courses for mining engineers, with large laboratories for the reduction of ores to the metallic state, the same type of machinery being used as in a mine. Mining and metallurgy are often taken together; the metallurgy deals principally with copper, lead, silver and gold; the practical work, as regards iron and steel, appeared small when the industrial importance of these metals is considered.

The very large number of students to be found in one college is also significant. Canada is by no means a populous country, yet there are nearly three hundred engineering students at MacGill University, Montreal; and we find from two to five hundred students at all the leading technical institutions; yet in spite of these large numbers, the supply of graduates seems to be unequal to the demand. Almost every graduate can at once obtain a post carrying with it a salary small, but generally sufficient for an independence.

It is difficult for an outside observer to form an absolutely accurate idea of American methods of teaching, but they certainly rely to a greater extent than we do on text-books, and a considerable amount of home work seems to be the rule.

The recitation class, in which students are questioned on the matter of the text-book, is quite unlike anything in England; it is intended to give the teacher a means of discovering what the student knows, and as marks are assigned for success in recitation, it plays an important part in the course. The written examination does not appear to carry the weight that it does with us; no practical or drawing examinations are held, but every piece of work is marked and counts towards graduation.

A special feature is the way in which the purely professional subjects are subdivided. Thus, at Boston, we find no less than seven engineering professors besides assistant professors. There can be no doubt that this specialisation is beneficial to both staff and students. To the staff it must be a great advantage to be able to concentrate themselves on a special subject, which, of course, they can carry further than if they were obliged to cover a wide ground. The subjects of thermodynamics, mechanism, and applied mechanics are really quite separate, although often grouped together under the head of mechanical engineering.

Looking on the system of American technical education as a whole, one cannot but be filled with admiration for the manner in which they have carried out their ideals. Technical education may be looked upon as similar to a manufacturing process; it should turn out a product of the particular kind that is required for the industrial needs of its own country. The actual educational value of the methods of training employed should be subordinated to the commercial question, which is, whether the student obtains that knowledge which will enable him to be of use in industry. In a system of general education the training of the mind is generally taken to be of more importance than the actual knowledge, but professional education stands on a different basis. If this point of view be taken, then the persons who decide on the value of technical education should be the employers into whose service the graduate passes after completing his college course.

American manufacturers who require scientific assistants appear to be perfectly satisfied with the education which is given to the students. In some of the largest works the heads of departments and designers are all college graduates, and in not a few cases important and responsible posts are reached at what seems to us a very youthful age. Part of the success of American manufactures in outside markets is no doubt due to the systematic and thorough technical training of those who direct their manufacture.

The American student works harder than his English confrère, and his work is mapped out for him along strictly utilitarian lines; for the average man the American system is exceedingly good; for the very good man it is doubtful whether it is not too rigid, which may explain why there are so few scholars and brilliant exponents of research produced in proportion to the large number of students. F. W. BURSTALL.

ARMOUR PLATES.

THE different classes of armour which may be used are as follows:—Wrought iron, steel, compound, Harvey, and Krupp types.

Wrought iron was largely used in the first armour-clad battleships, and the late Sir John Brown was practically the first manufacturer of them on a large scale in this country. Owing to its toughness and freedom from cracks under the impact from projectiles, this type held its own for a long time; it could be produced at a fairly cheap rate, and was readily worked into shape. Although attempts were made to employ steel long ago, owing to the higher cost of this material and the methods of fusion not being sufficiently perfected, until comparatively recently, to enable mild or soft steel to be produced—that is, steel low in carbon—this material did not make much way until, in France, methods were introduced of producing at one operation large masses of mild steel.

In this country, however, we branched off into compound plates—that is, plates composed of wrought iron with hard steel faces. There is no doubt, however, that the French policy was the better one, as mild steel plates, though perhaps more easily perforated, do not crack under impact to the same degree as compound plates.

Owing, however, to the enterprise of the American, Harvey, it was found possible to take soft steel plates and carburise them in a similar manner to that which has been used for centuries—that is, carburising by the cementation process (though, of course, Harvey's treatment was necessarily varied to suit the altered nature of the material being treated), so that steel plates were obtained with faces containing considerable percentages of carbon, up to ·70 or ·80 per cent., whilst the rear still retained its original soft and tough condition. Such a plate, after being treated and quenched in water, either wholly or on the hard side, then possessed a very hard surface, against which a shot broke into fragments.

Further improvements were introduced at Krupp's Essen Works, both as regards the composition of the steel used in the plates, a material being obtained of tough nature, yet having great tensile strength with high elastic limit, and also a further improvement was effected by carburising the surface by means of gas cementation instead of charcoal. More regular and uniform results have been thus obtained than by any other process, and though by means of specially shaped projectiles, or projectiles fitted with soft metal caps, such plates can be perforated, this is much more difficult than formerly. Ordinary ogival projectiles without caps go to pieces upon impact, their striking energy being wasted in breaking themselves instead of perforating the plate attacked. Briefly, it may be said that the latest type of hard-faced plates possess about twice the resistance of the older type of plates. This enables a great saving to be effected in the weight of armour to be used for the protection of the modern warship.

My firm has, however, recently produced capped projectiles which, with a slightly higher velocity than the average usually employed, readily perforate hard-faced plates, so that before long we may expect the latest type of plates to be found quite vulnerable. Thus the battle proceeds, first the plate wins, then the projectile, until perhaps some day all civilised nations may find it more profitable to revert to a simpler and more effective method of settling difficulties than by trying to kill each other. R. A. HADFIELD.

NOTES.

EXPRESSIONS of opinion from political leaders as to the value of scientific advice, and the need for scientific methods in Government Departments, are so rare, that some remarks which Lord Rosebery made upon this subject at Chatham on Tuesday come almost as a surprise. We have over and over again referred to the lack of interest in the progress of science, and the disinclination to take advantage of available applications, shown by official authorities concerned with national affairs. Only recently some of the scientific lessons taught by the war have been pointed out in these columns (pp. 37, 83), and some of the services which a committee of men of science could render to the Government if their advice were asked have been indicated. From the subjoined extract from Lord Rosebery's speech it will be seen that he is in accord with the methods advocated in these columns. If the war leads to an acknowledgment of the value of scientific opinion, the result will be one upon which the nation may be sincerely congratulated. The *Times* reports Lord Rosebery to have said:—"We ought to get another great advantage out of this war, for, after all, we in this country have much to learn, and this war will have been a cheap one, whatever it may cost, if it has made us learn several important lessons. I humbly think that in this country we live a great deal too much from hand to mouth. We do not proceed by scientific methods. We go on the principle that things have carried on so well so far, that we are a noble nation, that we are very rich, that we are pretty numerous, and that we have so muddled out right in the end. But I say this, that we are a people of enormous waste. We waste simply by not pursuing scientific methods. I do not like to compare us with Germany. It is hardly safe to mention the name of foreign Powers lest some innuendo be suspected, or else some guilty thought in one's mind. But at any rate we may be certain of this—taking Germany as an example of the opposite method of treatment—Germany is infinitely more painstaking and scientific in its methods than we are. But, without taking as a model Germany or any other country, I believe, if we wish to take full advantage of the lessons of this war after it is concluded, we must become more scientific in our methods in commerce, in education, and in war. We are not methodical, we are not scientific, we are not abreast of the more advanced nations of the day; and if we want to keep our place we shall have to consider the lessons we have been taught in this respect. Depend upon it, however brilliant you may be, the tortoise of investigation, method, and preparation will always catch up and overtake the hare which leaves everything to the inspiration and effort of the moment. Great as the task before us in the field is at this moment, the task that remains for us after this war is completed is the greatest task that ever lay before a nation. You will have, when this war is over, to put your Empire on a business footing. We must have no more discussions as to the way in which one thing has happened to go wrong or has happened to go right. We must consider, deliberately, patiently, and scientifically, the methods by which we have been accustomed to proceed, and

see in what way they have fallen short, and determine to reconsider and revise them."

PROF. H. G. ZEUTHEN, professor of mathematics in the University of Copenhagen, and M. Peron, of Auxerre, have been elected correspondants of the Paris Academy of Sciences.

WE notice with much regret the announcement that Prof. D. E. Hughes, F.R.S., died suddenly on Monday, January 22, at the age of sixty-eight.

SIR JOHN LUBBOCK, on his elevation to the peerage, has decided to take the name of Lord Avebury, after a property of his in Wiltshire. Letters Patent have been passed granting the adoption of this title.

DR. G. K. GILBERT, of the U.S. Geological Survey, has been elected president of the American Association for the Advancement of Science.

DR. GEORGE M. DAWSON, director of the Geological Survey of Canada, was elected president of the Geological Society of America at the annual meeting held on December 27, 1899.

THE death is announced, at the age of fifty-three, of M. Marion, Curator of the Natural History Museum at Versailles.

ON the 16th inst. two violent explosions occurred at the Avigliana dynamite factory near Turin, ten persons being killed and thirty injured. Both explosions were distinctly heard in Turin, although the distance is fully 25 km.

MR. C. A. SCHOTT, chief of the computing division of the U.S. Coast and Geodetic Survey, has retired from that post in order to devote his whole time to special scientific work. He has been succeeded by Mr. J. F. Hayford.

MR. J. B. CARRUTHERS has been appointed mycologist to the Government of Ceylon and assistant-director of the Botanical Gardens at Peradeniya. He will leave England early in March to take up his duties, which will chiefly be the investigation of the diseases of economic plants in the island.

DR KARL GOEBEL, professor of botany and director of the Botanical Institute at Munich, is now associated with Prof. E. Selenka and Prof. J. Rosenthal as editor of the *Biologisches Centralblatt*. All botanical communications intended for that periodical should be sent to Prof. Goebel.

M. DE FONVIELLE informs us that the solar halos and mock suns observed on January 11, and referred to in our notes last week (p. 279), were seen over a large part of Western France. A detailed description of the phenomenon, with illustrations, will appear in *Cosmos* of January 27.

THE distinguished diatomist, Dr. Grunow, has presented his very large collection of diatom-slides to the Imperial Natural History Museum at Vienna. A very carefully prepared selection of microscopic slides made by the late Mr. W. T. Suffolk has been presented by his representatives to the Royal Microscopical Society.

MR. WILLIAM HENRY POWER, F.R.S., the Assistant Medical Officer and Medical Inspector for General Sanitary Purposes of the Local Government Board, has been appointed to the office of Medical Officer of the Board, in succession to the late Sir Richard Thorne Thorne, K.C.B. Dr. H. Franklin Parsons has been appointed successor to Mr. Power, and Dr. R. Bruce Low has been appointed an assistant medical officer of the Board.

A REUTER telegram from Madrid, dated January 20, states that, in view of the declarations of the Minister of Public Works in the Chamber, the Spanish Government proposes to make the best possible arrangements at the Madrid Observatory for the reception of foreign astronomers, who will observe the eclipse of the sun on May 28. Nevertheless, other places are better adapted for the purpose, as, for example, Naval-Moral, 200 kilometres from Madrid on the Caceres line, because at that place the eclipse will be total for two minutes.

THE *Electrician* states that the Admiralty have determined to fit several vessels of the Channel Squadron, viz. the *Majestic*, *Magnificent*, *Hannibal* and *Jupiter*, with wireless telegraphic apparatus on the Marconi system; and the signal boatswains of the two flag-ships and two petty signal officers on each of the ships in question are now being instructed in wireless telegraphy on board the *Hector* at Portsmouth. It may be regarded as extremely probable that all the vessels of the navy will eventually be equipped with wireless telegraphic apparatus.

SCIENCE has suffered a considerable loss by the death of Mr. James R. Gregory, whose services to mineralogy are widely known. Mr. Gregory was born on December 29, 1832, and while a boy at school he showed great interest in minerals and fossils. He started his active career as an expert in gems, but afterwards took up mineralogy and geology, and got together some valuable collections. In 1867 he went to South Africa prospecting for minerals, and introduced from there the crocidolite. He exhibited a collection of minerals at the Paris Exhibition in 1867, and was awarded a medal. He also exhibited at the Fisheries and Health Exhibition, and wrote the report on minerals and gems for the Indian and Colonial Exhibition. In addition to many rare mineralogical and geological specimens, Mr. Gregory possessed a fine collection of meteorites, which he had been getting together for about forty years. He was a member of several scientific societies, and had sincere regard for the progress of natural knowledge.

INCORRECT maps and neglect of compass bearings are two of the causes to which the *Times* correspondent attributes General Gatacre's repulse at Stormberg. As science is concerned with both these matters, we reproduce the correspondent's remarks upon them :—(1) The map of the ground was utterly misleading and worse than useless. Not only was the contouring so incorrect as to give a totally false picture of the configuration of the hills, but the actual distances and the roads were inaccurately represented. (2) So far as I am aware, no one amongst the responsible authorities had taken any compass bearings, and consequently no one knew where he was being taken in the dark.—The special correspondent of the *Times* at Cape Town thinks that the latter point is exaggerated, and remarks :—"Owing to the abundance of magnetic ironstone all over South Africa (and the name 'Rooi-kop,' 'red-head,' probably indicates its presence near Stormberg) compass bearings are liable to be all over the place, especially at night, when it is impossible to know how near one may be to magnetic rocks. At Chieveley one day I was taking some bearings which made Colenso lie due east instead of north, north for the nonce happening to be a large stone a yard or two away."

AN earthquake, resulting in great loss of life, occurred on September 20, in the neighbourhood of Smyrna. More than 1600 persons, it is estimated, were killed, and more than 2000 wounded, while 11,000 houses were destroyed. The epicentre appears to have been situated in the Meander valley between Aidin and Sarakeui, and a large number of the damaged towns and villages are situated in this valley within an area more than sixty miles long. The railway line between Aidin and Omourlou was raised by fully one yard, while in other parts of the valley the ground has sunk. Some additional details are given in a letter that we have received through a correspondent. "Practically every building within an area of 1200 square miles," he says

"was damaged to a greater or less extent—most being levelled to the ground. For instance, Denizli had 4500 houses, and of these 2400 are completely down; Sarakeui had 800, and of these 600 are down. . . . From a scientific point of view the earthquake was most interesting, and the cause or the consequences of it, was that the greater part of the Meander and Legens valleys have subsided from two to six feet."

ACCORDING to the *Listok* of Tiflis, the earthquake of December 31, 1899, which destroyed so many houses at Akhalkalaki (Transcaucasia) and in ten neighbouring villages, and during which more than 200 persons perished under the ruins of the houses, was well observed at the Tiflis Physical Observatory. The first shock was at 1h. 50m. 30s. p.m., and had the unusual duration of 1m. 4s. It was felt with special severity in the hilly part of the city, on the right bank of the Kura river. Lamps were set swinging in the houses, vessels fell from the cupboards, and heavy crosses went down from the bell towers of several churches. The direction of the shock was N.W. to S.E. The second, much feebler shock, was at 4h. 38m. 34s. p.m., and lasted four seconds only; its direction was N.N.W. to S.S.E. The third shock, at 8h 45m. p.m., was not shown by the seismoscope of the Observatory, which is situated on the left bank of the Kura, but was noticed on the right bank of the river. The earthquake was also noticed at the Tkvibuly, Tsipa, Varvarino and Kvirily stations of the Transcaucasian railway (from 1h. 47m. to 1h. 50m p.m.), where it damaged several station houses, as well as at the Kalagelan (1h. 48m.), Sviri and Zugdidi stations of the Kars railway (at 2h. 22m., at the two last ones), as well as at the high-level stations of Abas-tuman (4h. 50m.) and Kobi (2h. 1m.).

ONE of the wonders of the New York Zoological Park, recently opened to the public, is a great cage for birds. It represents an attempt to do for certain large and showy water birds precisely what has been done in the Park for the hoofed animals, the buffalo, the otter and other species—to give them all a section of Nature's own domains; and when the birds are finally put into the cage they will fly in real freedom, for it incloses three forest trees of considerable size. The structure is 152 feet long, 72 feet wide, 55 feet high, and consists of a series of steel pipe arches and purlins over which wire netting has been tightly stretched; chain netting is used so as to afford the least possible obstruction to the eye. It contains a pool of water 100 feet long and an abundance of shrubbery. Another important buiding is the reptile house, which is one of the finest structures ever erected in a zoological garden. It is 146 feet long, and its greatest width is over 100 feet; it cost about 45,000 dollars.

AT several stations on the Indian coast tidal curves are automatically recorded by means of self-registering gauges, and are used in the construction of tide-tables containing the predicted times and heights of high and low water at about forty ports. The report of the work of the Survey of India Department during 1898, which reached this country at the end of last year, contains tables showing the agreement of the actual with the predicted times and heights for each year of the period 1890–1897. Taking the averages of the eight years, it appears that at open coast stations, 71 per cent. of the predictions of the times of high water were within fifteen minutes of the actual times, and 70 per cent. of the low water estimates were within the same limits of accuracy. The estimated heights were more accurate, 95 per cent. of the predictions of the heights of high water being within eight inches of the observed height, and 93 per cent. of the low water heights were within the same margin of error. Of course, a difference of eight inches means more at some places than at others; nevertheless, the forecasts as a whole may be regarded as satisfactory.

FROM the annual report of the Royal Alfred Observatory, Mauritius, for the year 1898, we learn that the mean rainfall at seventy-one stations was 76·85 inches, against an average of 77·89 inches; the rainfall for the month of August was the greatest on record, and was highly beneficial to the sugar crop. There were apparently two tropical cyclones in the South Indian Ocean during the year, the tracks of which have been approximately laid down on a chart. The magnetographs were at work throughout the year; disturbances occurred on thirty-nine occasions; the principal were February 11–13, March 15–16, and September 9–11. Photographs of the sun were taken daily when the weather permitted, and the negatives were forwarded to the Solar Physics Committee. There were sun-spots on 302 days; the great feature during the year 1898 was the sudden outburst of activity in September, after a decided decrease as compared with the previous year. No brilliant auroræ were observed.

SO little is known of the fauna of British lakes that a paper on the Entomostraca of Lake Bassenthwaite, by Miss E. M. Pratt, published in "Studies in Biology from the Biological Departments of Owens College," is of distinct value. In an introductory note, Prof. S. J. Hickson refers to the possible practical value of this investigation to fishery. It is well known to fishermen that the lakes in Cumberland vary very considerably in their "trout" reputation. Bassenthwaite is not regarded as a very good lake for trout, but, on the other hand, it contains an abundance of perch and pike. It would be extremely interesting if in time a systematic study of the relations between the fish-fauna and the Entomostracan fauna could be undertaken. This would not be a very costly investigation, and Prof. Hickson thinks it would require the whole time of a competent naturalist provided with a modest laboratory on the lake side for a period of two or three years. Biology stands in great need of investigations of this kind; but though there are many willing workers, few funds are available to equip them and provide them with the necessaries of life while their researches are in progress.

THE subject of parasitism in freshwater mussels has been investigated by Mr. H. M. Kelly (*Bulletin Illinois Laboratory*, vol. v., art. 8), with the object of determining to what extent the degree of infection would vary in allied species in the same or different localities. The results seem to indicate that the capacity for being infested by each particular host is to a great extent a characteristic of the species.

THE first number of the *Revue Scientifique* (*Revue Rose*) for 1900 contains an account of the addresses delivered by well-known naturalists on the occasion of the "jubilee" of the Société de Biologie. An interesting survey of the history, growth, and work of the Society was given by MM. Bouchard and Gley, from which it appears that the progress in the past has been satisfactory, and that there is every augury for a hopeful future.

THE managers of the Marine Biological Laboratory of Wood's Holl, Massachusetts, have issued an attractive syllabus of the course of study and instruction in the department of botany for the thirteenth season, from July 5 to August 15, 1900. It comprises courses of lectures, together with a laboratory course of instruction by experienced teachers, on cryptogamic botany, plant physiology, plant cytology, and microtechnique, together with special lectures and courses of lectures by experts on branches which they have made their special study.

IN vol. iii. (No. 6) of the *Records* of the Australian Museum, Mr. R. Etheridge, jun., describes, under the name of *Blechnoxylon*, some remains of a curious fern-like plant from the Coal-

measures of New South Wales, indicating a totally new structural type. Fern-like in its general characters, this plant presents the peculiarity of developing secondary wood in its stem, so that we have the association of fern-foliage with a stem characteristic of higher plant-groups. It is suggested that it may prove to be allied to the so-called Cycado-filices of Dr. Potonié—organisms that appear to be on the border-line between the now well-differentiated groups of Cycads and Ferns.

IN the same journal, Mr. E. R. Waite records the occurrence, on the coast of New South Wales, of an example of the rare Ribbon-fish, or Oar-fish, of the genus *Regalecus*. Like all other known specimens, the present example was imperfect, and belonged to the female sex. As is well known, there is great variation in the relative length and breadth of the body, as well as in the number of the fin-rays, of the different specimens of *Regalecus* hitherto obtained; but Mr. Waite seems favourably inclined to the view that such differences are only of individual value.

IN the *Atti dei Lincei*, viii. (2), 11, Prof. Pietro Tacchini gives statistics of the earthquake which occurred at Rome on July 19 of last year, and Dr. G. Agamennone discusses the Emilian earthquake of the night of March 4–5, 1898, the epicentre of which was situated in the Apennines. Dr. Pericle Gamba contributes a brief account of the magnetic properties of bricks, &c., that have been struck by lightning, and his observations are in conformity with the theory that the singular points and zones ("punti distinti e zone distinte") observed in rocks and bricks are only produced in a powerful magnetic field, such as is due to violent discharges of atmospheric electricity, and that their magnetisation is independent of the earth's magnetic field. These conclusions accord with the views of Dr. Folgheraiter.

AMONG the various properties of multi-dimensional space, the analogues of the five regular polyhedra are of interest. In the *Verhandelingen* of the Amsterdam Academy, M. S. L. van Oss discusses the "regular 600-cell," *i.e.* the form bounded by 600 tetrahedra, which can exist in space of four dimensions. The paper, which deals also with the self-congruent displacements of the form in question, is illustrated by fourteen plates, showing the figures of the 600, the 120, and other regular forms in four-dimensional space, so far as these can be made visible by their projections on two mutually independent rectangular co-ordinate planes.

WE have received an elaborate memoir, by Dr. Wilhelm His, on protoplasmic studies of the ova of the salmon, published in the *Abhandl. Sächsischen Gesellschaft*, 1899, No. 3.

AS we learn from the Report of 1899, the Bristol Museum has been enriched by a fine series of Neolithic implements and weapons presented by Mr. J. E. Pritchard, by whom they were collected in Somerset and the adjacent counties. The same institution has likewise received an unusually fine skeleton of an Ichthyosaurus.

FROM Rome we have received a copy of *Vox urbis*, a periodical in Latin, mainly devoted to literature and fine arts, and published fortnightly. The present number is illustrated by views of Orvieto Cathedral, and the contents, which border most nearly on science, are short articles by R. Spina, on "Telepathy," and by A. Costaggini, on artificial gems.

THE first part for the current year of the *Proceedings* of the Washington Academy of Sciences consists of a synopsis of the Mexican and Central American Umbelliferæ, by Prof. J. M. Coulter and Mr. J. N. Rose, illustrated by several plates and numerous text-figures.

THE number of *La Nuova Notarisia* for January contains a biographical sketch, by Prof. G. B. De Toni, of the late Count Abbé F. Castracane, together with a complete list of his contributions to botanical literature. This occupies five pages of close print, and comprises upwards of one hundred and twenty separate papers, of which by far the larger number refer to the structure, reproduction, and mode of life of diatoms.

FROM Dr. A. Fock, of Berlin, we have received a pamphlet of 128 pages, entitled "Ueber die Grundlagen der exacten Naturforschung." It is a philosophical dissertation dealing with the fundamental conceptions of number, magnitude, length, time, mass, force and energy, the doctrine of causality, the atomic theory, the ether, and so forth, and it gives us the general impression of being well written and clearly expounded. Messrs. Mayer and Müller, of Berlin, are the publishers.

A FOURTH edition of the "Lehrbuch der Botanik für Hochschulen," by Profs. Strasburger, Noll, Schenck and Schimper, has just been published by the firm of Gustav Fischer, Jena.

A "LIVERPOOL MATHEMATICAL SOCIETY" has recently been established. At a meeting held on January 12, at the University College, Prof. Sircom read a paper on some hydrodynamical problems.

A NEW and enlarged edition of the Rev. James Gall's "Easy Guide to the Constellations" has just been published by Messrs. Gall and Inglis. The book provides a simple means to enable any one to become familiar with the constellations and the individual stars represented upon the thirty small maps.

MESSRS. HENRY HOLT AND CO., New York, announce for immediate publication Atkinson's "Lessons in Botany" and Barnes' "Outlines of Plant Life." Both books are simplified and abbreviated editions of earlier books by the same authors, and are adapted to the needs of pupils in secondary schools.

A CLASSIFIED list of separate papers from the various publications of the Smithsonian Institution, at present available at a nominal price, has just been distributed by the Institution. The papers will be supplied, by preference, to persons engaged in original research in the branch of science to which the work asked for pertains, to those engaged in educational work, and to collaborators of the Institution.

THE preface of the thirty-fifth volume of the "Zoological Record" contains the important announcement by the editor, Dr. David Sharp, F.R.S., that "This volume includes the literature of the Cœlenterata for two years, and brings the indexing of all the branches of zoological literature up to date." The volume was published towards the close of last year, and relates chiefly to the zoological literature of 1898.

MR. WILLIAM CROW, of Stratford, has issued a "century chart," designed to indicate that the nineteenth century does not end until the completion of this year. The chart shows 100 years marked upon a dial, the zero point being at the place where the figure XII. usually occurs on the face of a timepiece. The zero thus represents the dividing line between the end of one century and the beginning of the next, and a hand drawn upon the chart to indicate the position of the present year is shown to have to reach the zero again to complete the nineteen hundredth year.

AMONG the other scientific books in preparation at the Clarendon Press, the following are noteworthy:—"The Structure and Life-History of the Harlequin Fly," by Prof. L. C. Miall, F.R.S., and Mr. A. R. Hammond; "Physical Aspects of Soils," by Prof. R. Warington, F.R.S.; "A Catalogue of Eastern Lepidoptera Heterocera in the Oxford University Museum (Part II. Nocturna)," by Colonel C. Swinhoe; Goebel's "Organography of Plants," translated by Prof. J. Bayley

Balfour, F.R.S.; and "A Textbook of Arithmetic," by Mr. Richard Hargreaves.

A NEW monthly magazine—*The International Monthly*—made its appearance at the beginning of this year, the publishers being the Macmillan Company. The periodical is a serious addition to contemporary literature, and contains instructive essays on progress in several departments of knowledge. Science is represented by an article, by Prof. N. S. Shaler, on the connection between solar energy and terrestrial formations and phenomena; and Prof. John Trowbridge gives an outline of recent advances in physical science. For each department of the magazine, there is an editor in France, another in Germany, and a third in England, as well as one in the United States.

A SERIES of monthly star maps, prepared by Mr. Walter B. Blaikie for the Scottish Provident Association, provides a concise source of reference to the ordinary observer not possessing any special astronomical knowledge. The maps give a planispheric projection of the heavens, as seen from London, for the first day of each month at 10 p.m., each map being divided into two portions, showing the northern and southern aspects respectively. A considerable amount of useful information is given in the letterpress accompanying the maps, including short descriptions of the more interesting celestial objects, and particulars respecting the planets visible during each month.

THE sixth volume in the biological collection of the "Scientia" series of scientific treatises, published by Messrs. G. Carré and C. Naud, Paris, is concerned with the "Evolution du Carbone et de l'Azote," by Dr. P. Mazé. The three chapters which make up the volume deal respectively with the origin of carbon in the organic world, the origin of organic nitrates, and the decomposition of organic compounds. Many subjects of interest to chemists and plant physiologists are passed in review: for instance, the mechanism of carbohydrates in leaves by means of diastasis, the assimilation of the organic carbon from the soil, and formation of fatty substances, the formation of the quaternary compounds in the higher plants, and the relation of various forms of life to the proportion of carbon dioxide in the atmosphere.

MESSRS. WILLIAMS AND NORGATE'S current "Book Circular" contains the following announcements:—Dr. R. Hartig has thoroughly revised his "Lehrbuch der Baumkrankheiten," and will shortly issue the third edition under the title "Lehrbuch der Pflanzenkrankheiten."—A second revised and enlarged edition of Dr. Julius Wiesner's "Die Rohstoffe des Pflanzenreichs" is in preparation. The first part will be issued shortly.—Dr. Eugen von Halácsy will publish very shortly the first part of a flora of Greece, Epirus, and the Ionian Islands, under the title of "Conspectus Floræ Græcæ." The first instalment will consist of some 160 pages, and it is expected that the work will be complete in about eight parts.—The first part of the handbook of the Siphonogamæ, by Drs. Dalla Torre and Harms, will very shortly be published under the title "Genera Siphonogamarum."—A supplementary volume to Beilstein's "Handbuch" is being prepared by the German Chemical Society under the editorship of Prof. Paul Jacobson, and will be issued in parts during this year.

THE system of determining latitudes by observing at groups of stations close together instead of at a single station, was again given a trial by officers of the Survey of India department in 1898, and is referred to in the report which has recently been published. The system originated with Lieut. J. Herschel, several years ago, but was allowed to drop, because that officer was removed from the work before he had fully elaborated it. For the new experiments the longitudinal station at Agra was selected as the central point, but for reasons which had not been foreseen it was found impossible to connect the outlying stations by a sufficiently rigorous triangulation for a proper comparison of the observed and computed azimuths. The latitude observations led to interesting results, and opinion is expressed that in more favourable country the system will prove highly valuable.

THE dilution law given by Ostwald in 1888, $K = \frac{\alpha^2}{(1-\alpha)V}$ (where α is the percentage dissociation and V the volume of liquid containing one molecular weight of the binary electrolyte), was a most important step forward in the study of solutions. But as further investigations were made on this subject, it was found that this dilution law holds only for weak acids and bases, and not for salts, strong acids and strong bases. The Ostwald expression was derived directly from the law of mass action, but subsequent attempts to modify it in the direction of including strong electrolytes were empirical. Thus Rudolphi's $K = \frac{\alpha^2}{(1-\alpha)\sqrt{V}}$, and van 't Hoff's $K = \frac{\alpha^3}{(1-\alpha)^2 V}$ were advanced in 1895, and the latter, which can be more compactly written $K = C_i^3/C_s^2$ (where C_i denotes the volume concentration of the dissociated portion and C_s that of the undissociated salt), represents the facts fairly well for "strong" electrolytes. Since there is no sharp line of demarcation between strong and weak electrolytes, it follows that there must be electrolytes which are on the border line between these two classes, and for which neither formula holds with accuracy. In the current volume of the *Zeitschrift für physikalische Chemie*, Dr. W. D. Bancroft seeks to replace these by a third formula, which, though empirical and indeterminate, may describe all binary electrolytes. This formula is $K = C_i^n/C_s$, including both the Ostwald and van 't Hoff expressions as special cases. Dr. Bancroft points out that the simplest way of determining whether the general formula $K = C_i^n/C_s$ does or does not apply is to plot the value of log C_i against log C_s as ordinates. If the formula applies, the resulting curve will be a straight line, and the slope of the line gives the value of n. Values are given in the paper for solutions of potassium, sodium, lithium, ammonium and hydrogen chlorides, sodium potassium and silver nitrates, potassium iodide and caustic potash, and with the exception of the most concentrated solutions, the data lie absolutely on straight lines; the values of n found varying from 1·36 to 1·55. A theoretical explanation of these facts would be of the greatest interest.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mr. A. Althorp; a Woodcock (*Scolopax rusticula*), British, presented by Mr. W. A. Beauclerk; a Short-eared Owl (*Asio brachyotus*) captured in the Indian Ocean, presented by Dr. A. E. Prest Hughes; two White-headed Sea Eagles (*Haliaetus leucocephalus*) from North America, presented by Mr. Henry Anger; a Laughing Kingfisher (*Dacelo gigantea*) from Australia, presented by Mr. J. Kirkland; two Triangular-spotted Pigeons (*Columba guinea*) from South-West Africa, presented by Mr. J. Parminter; two Wagler's Terrapins (*Hydraspis wagleri*) from Brazil, six Blanding's Terrapins (*Emys blandingi*), a Grass Snake (*Contia vernalis*), a Mocassin Snake (*Tropidonotus fasciatus*) from North America, a Flat-backed Tortoise (*Testudo platynota*) from Burmah, an Indian River Snake (*Tropidonotus piscator*), an Indian Eryx (*Eryx johni*) from India, ten Reeve's Terrapins (*Damonia reevesi*) from China, two —— Chelodines (*Chelodina*, sp. inc.) from Australia, a Royal Python (*Python regius*) from South-West Africa, deposited; eight Burrowing Owls (*Speotyto cunicularia*) from South America, purchased.

OUR ASTRONOMICAL COLUMN.

DENSITY OF CLOSE DOUBLE STARS.—Many authorities hold the opinion that the mean density of close double stars is in general low as compared with that of the sun. In the *Astrophysical Journal* (vol. x. pp. 308–318) there are two papers, by Messrs. A. Roberts, of Lovedale, South Africa, and H. N. Russel, of Princeton, U.S.A., which examine mathematically the possible limiting values of the densities of those double stars constituting the Algol type of variables. The limiting value for the mean density of the star is calculated from the observed *period* and *duration of light variation*. The results obtained independently by the two authors are, considering the uncertainty with which many of the periods of variation are known, fairly well in agreement. The general conclusion is that these variables of the Algol type are probably more than five or six times less dense than the sun.

A NEW PHOTOGRAPHIC PHOTOMETER.—Dr. J. Hartmann describes in the *Astrophysical Journal* (vol. x. pp. 321–332) a new photographic photometer he has devised for use at the Potsdam Astrophysical Observatory, in the determination of stellar and other magnitudes. The difficulties involved in previous instruments—viz. distance between standard scale of intensities and portion of plate to be measured, apparent alteration of intensity owing to surrounding parts of plate—have been eliminated by employing a broken microscope, the two objectives of which feed a single eyepiece with the images of the standard scale and the portion of the plate under examination; and, by arranging small apertures over both scale and plate, practically all contrast effect is got rid of. The double microscope enables the two regions to be optically in juxtaposition, so that the point of equalisation of intensity can be found with great precision.

A BRILLIANT METEOR IN SUNSHINE.

ON Tuesday afternoon, January 9, at 2h. 55m. p.m., when the sun was shining brightly in a cloudless sky, a large meteor was observed as a conspicuous object by many persons in the south-eastern part of England. Moving in a direction from west to east, it dashed rapidly across the southern sky and finally terminated its career, as observed from several places in Surrey and Kent, when situated under the moon, then in E. by S., altitude about 33°. The rarity of a daylight fireball, and the astonishing brilliancy it must exhibit to enable it to present a striking aspect even in the presence of the sun, lends a special interest to the phenomenon, and makes it desirable to collect all the particulars concerning it.

I have seen about fifteen descriptions of the meteor, and they nearly all emanate from the counties of Surrey, Kent and Sussex. Three of these accounts have already been quoted in NATURE of January 18, and the remainder, in a summarised form, are as follow :—

Maida Vale, London, W. Time 2h. 59m.—Apparent course of meteor due W. to E. First appeared in S.S.W., and disappeared somewhat to the right of the moon. Track nearly horizontal, about 25° altitude. Nucleus elliptical; long tail; colour silvery; no sparks or explosion.—J. G. WOOD (*Times*).

Warlingham, Surrey. Time about 2h. 30m.—A very conspicuous meteor passed from about S.W. to N.E., and vanished almost under the then position of the moon. It was about 45° from the horizon, and its line of movement curved downwards. Colour very white, reminding one of burning magnesium wire. It was rounded in front and tapering to a tail, leaving a few sparks behind, but no cloud.—F. BENNETT (*English Mechanic*).

Guildford, Surrey. Time 2h. 53m.—The meteor was first seen to the S. [? W.] of the moon, and two-thirds of the distance from the earth between the moon and the earth, and moved downwards towards the N., and vanished exactly underneath the moon. The lowest star of the three stars in Orion's sword was as near as possible in the place where the meteor vanished, at 5h. 45m. p.m. The head was very bright, pure white, and appeared about 3 inches across. It left a faint tail. It went out and did not burst.—C. J. CARELESS.

Earlsfield, S.W. Time between 2h. 50m. and 3h.—A yellow meteor shot from the right-hand side of the moon downwards, disappearing under the moon. The duration was estimated as between 3 and 4 seconds.—Correspondent of *English Mechanic*.

Beckenham, Kent. Time 2h. 55m.—A brilliant meteor passed across the sky at about 60° above the horizon, and in a general direction from a little to the N. of W. to the S. of E. The meteor was very distinct, and apparently of large size. It comprised a head and a brightly glowing body, which, as it travelled, appeared to throw off flakes of flame. The meteor, leaving a trail of bright light behind it, vanished, as it seemed, quite low down.—EDWARD KINGSHALL (*Daily Graphic*).

Penshurst, Kent. Time 2h. 57m.—Brilliant meteor seen here like a ball of burning zinc, emitting yellow sparks. Seemed to move from S.W. to N.E. Vanished almost direct under moon. Path appeared perfectly horizontal. The meteor broke up as it travelled, fragments flying from it much yellower than the mass in front.—THOMAS PARKER (*English Mechanic* and letter to W. F. D.).

Dunstable.—The daylight-meteor was seen here by my grandson, aged 14, who says it fell almost vertically (?) from a N. or slightly N.W. direction. It resembled a very large, brightly luminous, white kite with a long tail. It seemed to fall straight on to the houses of this town.—WORTHINGTON G. SMITH (letter to NATURE).

Eastbourne, Sussex. Time between 3h. and 3h. 30m.—A very bright meteor rapidly traversed the sky from a little W. of S. to a little N. of E. The transit was very rapid, and the direction slightly curved downwards. I saw it from the front, between the Wish Tower and Beechy Head, and it disappeared over Hastings. It passed just below the moon. In spite of the sunshine the meteor showed with an intense white brilliance. The tail was long and feathered.—H. E. SQUIRE (letter to W. F. D.).

Worthing, Sussex. Time between 3h. and 4h.—As I stood facing E. I saw something fall like a rocket downwards, running from S. to N. The head was large with a very long tail; the light was similar to electric light.

Pyecombe, Sussex. Time 2h. 55m.—As my brother was on his machine from Poynings, he noticed a meteor which appeared to come from the moon, in the form of a ball of red and blue fire, taking a course due northwards, and leaving a trail of light behind it for some considerable time.—A. REED (*Sussex Daily News*).

The meteor was also seen at Weybridge, Surrey, darting towards the N. It resembled a huge diamond with a long pointed tail.

I have been in correspondence with Mr. Bouverie, who saw the meteor at Lewes, and with the Rev. R. Hudson, who noticed it from Brighton (NATURE, January 18). The former says the meteor took a course from the lower side of the moon at an oblique angle towards N.E. The observer at Brighton says the first appearance was 5° or 7° below the moon, and the path sloping downwards from S.E. to N.; estimated track from 50° alt. when first seen to 30° at disappearance behind houses in N.

It was a very fortunate circumstance that the moon enabled the place of the end point of the meteor to be correctly assigned. But the descriptions are, as usual in such cases, somewhat discordant; and the only alternative is to adopt a path which approximately satisfies the observations. There is no doubt that the meteor was descending, though not at a large angle, and that the earliest portion of the flight was over the S.S.W., as observed at Maida Vale and Eastbourne. Several observers evidently did not notice the first part of the path, and thought that the meteor commenced its visible flight from a place very near to the moon.

The radiant point was probably at a rather low altitude in the S.W. sky. It could hardly have been farther south, as the long path and rapid motion oppose such a view. Observations from the N. coast of France would be very useful in settling the question. I have derived the following figures for the real path, which may be regarded as provisional, and liable to revision if further descriptions come to hand.

Meteor began—59 miles in height, over a point 10 miles east of Valognes, near Cherbourg, France.
Meteor ended—23 miles in height, over Calais, France.
Length of path—175 miles.
Radiant point—280° – 12°.

The actual velocity is doubtful. An observer at Reigate Heath says the meteor "was visible for about a second," though "it traversed a considerable portion of the heavens." At Earlsfield, S.W., the duration was roughly estimated as 3 or 4 seconds. Several observers say it moved "rapidly."

SOME RECENTLY DISCOVERED SILURIAN FISH REMAINS. A LINK IN THE CHAIN OF ORGANIC EVOLUTION.[1]

EVER since the days of Agassiz and Murchison the subject of the Lower Palæozoic Fish Fauna has been the most sensational in the department of Palæichthyology, mainly on account of the existence at that early period of forms known as Cephalaspidian and Pteraspidian (Osteostraci and Heterostraci of recent classifications), so strangely constituted as to be well-nigh irreconcilable with any of our recent and more familiar fishes. Analogy to certain living species (ex. Coffer Fishes) seemed to suggest that, though archaic, these forms are among the most specialised of all known fishes, and while there has been a general consensus of opinion that this may be so, recent tendency has gone to regard them as the specialised representatives of an ancient and primitive stock, believed by some to have been aqnathous, and even akin to the Lampreys and Hags, which in our modern classificatory systems are not admitted to the Class Pisces at all.

Pander, McCoy and Huxley are among the names of past-masters memorably associated with the record of their early discovery; and, in later years, Powrie, Lankester, Jaekel, Reis and others; while Rohon has quite recently made them the subject of far-reaching generalisation in cephalogenesis, which, though extravagant, has sufficed to maintain their unique interest. Great though the memoirs of these and other investigators as concerning these strange organisms, none of them, from a point of view of general interest and accuracy of detail, excel those of the author of the two under review, our foremost authority in Palæozoic Ichthyology. His descriptions and restorations of these creatures are everywhere reproduced, and it is matter for sincere congratulation that he should recently have been compelled to return to their study.

Most particularly does the above remark apply to the Pteraspidiæ, with the determination of the systematic position of which the monographs before us are mainly concerned, and the conclusions arrived at are the more welcome, in view of a recent attempt to deduce, from the discovery of supposed resemblances in the minute structure of their plates and the exoskeleton of the King Crabs, a belief in a genetic relationship between the two—one of those notoriously flagrant flights of fancy which during recent years have done so much to bring pure morphology into unjust ridicule. Needless it is to say that the author of the memoirs dismisses this as unfounded.

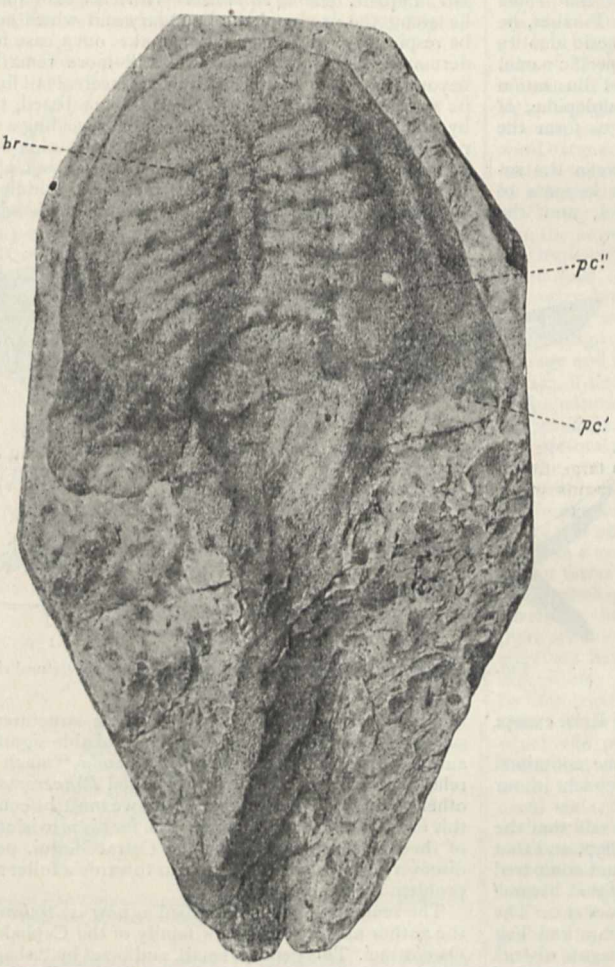


FIG. 1.—*Thelodus Pagei*, dorsal aspect, one-third natural size.

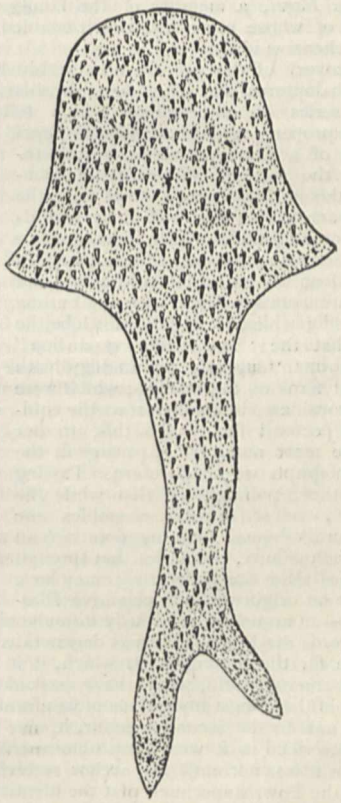


FIG 2.—*Lanarkia spinosa*, restored outline, with spines, half natural size.

Conspicuous among Dr. Traquair's later papers on these remarkable forms is that describing (*Proc.* Roy. Phil. Soc. Ed., vol. xii.) a giant Cephalaspis (*C. magnifica*) from the Old Red Sandstone of Caithness. At the time of its appearance (Dec. 1893) it seemed to those interested to give promise of further unique material from the Scottish Palæozoic; and, sure enough, in his penultimate discourse as Swiney Lecturer, the author, on October 12, 1898, announced at South Kensington the discovery of the remains here under consideration. At that lecture he dealt fully with the long known Cœlolepis scale, and dissipated the anomalies which had hitherto beset it, showing it to

[1] "On *Thelodus Pagei*, from the Old Red Sandstone of Forfarshire," and "Report on the Fossil Fishes collected by the Geolog. Survey of Scotland in the Silurian Rocks of the South of Scotland." By R. H Traquair, LL.D., F.R.S., being Nos. 21 and 32 of Part 3, vol. 29, *Trans.* R. Soc. Edinb.

be the shagreen granule of a remarkable fish—shark-like though not a shark; for while possessed of an expanded pectoral and an apparently heterocercal caudal fin, of an extensive branchial apparatus consisting (*br.*) of seven or eight sets of parts, it revealed no trace of teeth, jaws, fin-spines, or pelvic fins; while median fins other than the caudal could not be recognised. The impression created by this announcement was profound, and from the context of his remarks it became evident to the zoologists present that there had been discovered new and probably annectant forms of unique value, and that their best hopes of the Scottish Silurian deposits might yet be realised.

Shortly after his return to Edinburgh, the lecturer produced the first of the two memoirs under review, and therein announced that the fish in question is that described some thirty years ago by Powrie, its discoverer, from the Lower Old Red Sandstone at Turin Hill, near Forfar, by him named *Cephalopterus*, and which he himself, noting that that name was preoccupied, had in 1896 re-named *Turinia*. Further, he announced the very important discovery of its generic identity with Agassiz's *Thelodus*, and, retaining Powrie's specific name, put it finally forward with adequate description and illustration as *Thelodus Pagei*, a member of the family Cœlolepidæ, of the nature of whose representatives it enabled us to form the first comprehensive idea.

This discovery of the generic relationship between the so-called Cephalopterus and Thelodus furnished the keynote to the main series of observations which followed, and the author very properly made the *Thelodus Pagei* the subject of a first special memoir, introductory to the second. Towards the conclusion of this he lays special stress upon the peculiar characters of that which he regards as its pectoral fin-fold, which, according to his description, would appear (Fig. 1, *pc.'pc.''*) to extend along the branchial free border, and to be "continuous anteriorly with the outline of the head"; while, of its posterior lobe, he remarks that the "lappet-like expansion" which it forms "suggests an analogy with the cornual flaps of *Cephalaspis*, which were originally considered by Lankester as the equivalents of pectoral fins." To this, to our reading the most noteworthy, passage in the whole monograph we shall return. Passing on, the author, pointing out that while the Cœlolepid in most respects resembles the Pteraspidian its dermal covering points to an Elasmobranch affinity, concludes that through the Thelodus allies the Heterostraci may have had a common origin with the primitive Elasmobranchs—an argument previously formulated by Reis, except that he regards the Pteraspidians as degenerate.

So much for the first memoir, which, if it alone contained all that has come to hand, would have marked an epoch in our knowledge of these most mysterious of fish forms.

Turning now to the second memoir, it may be said that the materials described in it were only obtained in 1897, and that the fact that it was not until the author received and compared these with the Powrie specimen that the identity of that became evident. Hence the delay in the final determination of this. The 1897 collection was obtained by Messrs. Macconochie and Tait while searching the Silurian Rocks of the Lesmahagow district of Lanarkshire, and it was by the latter gentleman supplemented in 1898 by material which included one of the new genera. The total yield has been five genera, of which four are new, and eight new species, and in the earlier part of the monograph the author, retaining the ordinal name Heterostraci for the Cœlolepid and Pteraspidian forms, extends the definition of the former, regarded as a family of the order, so as to include *Thelodus* and the first of his new genera, *Lanarkia* (Fig. 2). Of Thelodus two new species (*T. Scoticus* and *T. planus*) are recorded and described, and of *Lanarkia* three species. All are small, and *Lanarkia* is characterised by the presence of a dermal armature consisting of relatively large conical spines, without a basal plate (*cf.* Fig. 2).

For the reception of the remaining three genera, the author has found it necessary to create a new family, the *Birkeniidae*, and a new order, the *Anaspida*, setting aside for the moment yet another remarkable form, for which the formation of a new family of the Cephalaspidians or Osteostraci has been found necessary. To deal firstly with the Anaspida, the most remarkable character which the two genera (*Birkenia* and *Lasanius*) possess in common is the possession of a series of median ventral scutes extending along the greater length of the trunk, and bearing each, throughout the posterior series in *Birkenia* (Fig. 3) and their whole extent in *Lasanius* (Fig. 4), a broad compressed spine of formidable aspect. Beyond this very remarkable character they differ *in toto*. *Birkenia*, possessed of a heterocercal caudal fin and a single dorsal, which (*d.*), with its body, is encased in a dense armature of elongated scutes, at first sight suggests, as the author naïvely remarks, a Palæoniscid "with the rows of scales running the wrong way!" The characters of its head scutes, the absence of recognisable mouth, of teeth, jaws and operculum, the non-certainty of orbits, however, altogether outweigh these superficial appearances as criteria of affinity, and Dr. Traquair, dealing *en passant* with a series of apertures, which lie along the post-cephalic boundary and which he thinks may be respiratory, with justification makes out a case for an ostracodermatous kinship. *Lasanius* is still more remarkable; since, beyond the row of scutes and the heterocercal tail fin, upon which its presumed affinities with *Birkenia* are based, the specimens by which it is represented agree only in revealing a series of eight post-cephalic skeletal rods, which (*r.*) slope obliquely forwards, and by a forwardly directed series of processes approach their fellows of the opposite side near the dorsal middle line. They are serially disposed behind an oblique chain of ossicles (*r.'*), and

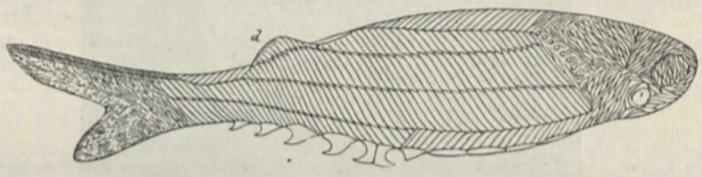


FIG. 3.—*Birkenia elegans*, restored outline, natural size.

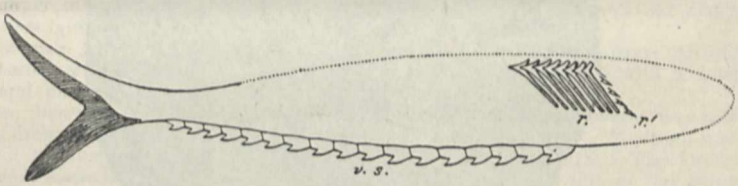


FIG. 4.—*Lasanius problematicus*, restored outline, about natural size.

remarkable in the extreme as are these structures, there is no suggestion forthcoming as to their probable significance. The author points out that *Lasanius* stands "much in the same relation to *Birkenia* as the nearly naked *Phanerosteon* does to the other genera of Palæoniscidæ," and we must be content to accept this on his authority, as justification for his provisional association of these strange genera with the Ostracodermi, pending further discovery, which can alone help us towards a fuller solution of the problem they present.

The remaining genus described as new is *Ateleaspis*, for which the author also creates a new family of the Cephalaspidian order Osteostraci. This genus is small, and beset by "shagreen bodies" which on the head have "coalesced into small polygonal plates" that in the tail region unite to form "flat rhombic scales." It is further remarkable for the joint possession of the configuration of a Thelodus or Lanarkia, and of a couple of crescentic markings on the top of its head which the author is inclined to regard as the "outer margins of a pair of orbits, placed as in Cephalaspis" (such as he has failed to detect in any of the other associated genera described in his monograph as new).

Passing on to general questions of classification and final consideration of the inter-relationships of these noteworthy creatures, Dr. Traquair hesitates, to our thinking rightly, to admit the Pterichthyidæ members of the Sub-Class Ostracodermi, apparently retaining this for the reception of the Pteraspidian and Cephalaspidian forms and their allies alone. The main outcome of his work is the association of the former with a supposed Plagiostome ancestry through the Cœlolepidæ, and he is led to find connecting links in the Drepanaspidæ, upon the Pteras-

pidian affinities of which he insisted in 1896. The sole representative of this family, *Drepanaspis*, from the Lower Devonian of Gmünden in West Germany, was only described by Schlüiter in 1887. We append a figure of it, from which it will be seen that while in respect to the possession of central (*c.*), lateral (*p.l*) and rostral (*r.*) plates it "points forwards" to the Pteraspidian type, in the possession of tesseræ it "points backwards" to the Cœlolepid; and by appeal to the condition of the Psammosteidæ, which the author holds to be near related forms, the "stellate tubercles" of which he has already come to regard as "shagreen-granules which have coalesced," he builds up an argument for the origin of the plates of the higher Pteraspidians by fusion of shagreen-granules in linear series.

Having thus with much justification strengthened his conviction that the Pteraspidian fishes have had a common origin with the primitive Elasmobranchs, and that the Cœlolepidæ, Psammosteidæ and Drepanaspidæ are in order representative of the ascending series which lead up to the Pteraspidians proper, the author returns to the consideration of the Cephal-

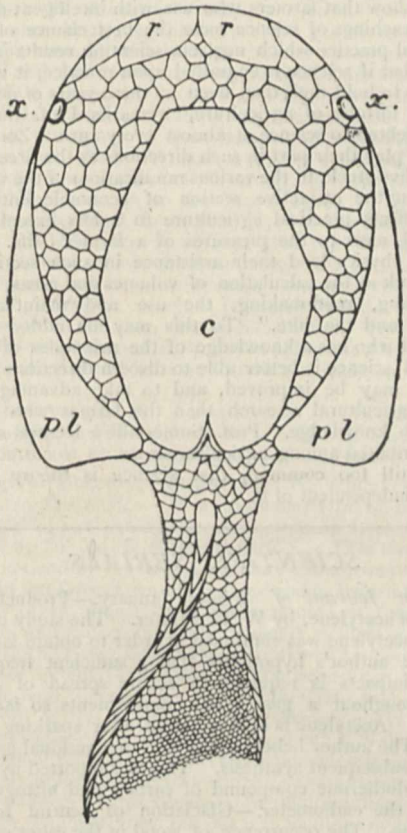


FIG. 5.—*Drepanaspis Gmündenensis*, restored outline, dorsal aspect, omitting surface ornament. *x* = orbit.

aspidians, and, recalling the points of structural community between the aforenamed *Ateleaspis* and the Cœlolepidæ, he concludes that between the Pteraspid and Cephalaspid groups there is, "after all, an actual connection."

As might have been expected, he incidentally rejects Claypole's alleged discovery of paired fins in *Palaeaspis*.

It will be remarked that the central point on which the conclusion as to the common origin of the primitive Elasmobranchs and the Ostracodermi (using this term in the author's sense) turns, is the homologising of the plates of the higher Pteraspidians with those of the less fully developed Drepanaspid and Psammosteid types. So far as the central and rostral elements are concerned well and good; but while admitting the assumed homology of the coronal plate of Pteraspis with the postero-lateral of Drepanaspis, we do not feel so sure about regarding these as the results of encasement of the lateral fin-flaps of Thelodus and Lanarkia, which are rendered thereby "utterly functionless as fins by being enclosed in unyielding bony plates." In dealing with these facts, Dr. Traquair has been led into a digression, savouring of leniency towards the lateral fold theory of the origin of the vertebrate limbs, to which indeed he has already expressed himself favourable in his recent memoir on the Selachian Cladodus Neilsoni. Following Powrie, he draws attention to the resemblance between the supposed fin-fold of Thelodus and that of the living Rays. If in this he is right, the characteristic feature of both is the forward extension into the head-region; and when it is remembered that ontogenetically the pectoral fin bud arises post-branchially, this extension can only be the result of forward rotation, and therefore an index of extreme specialisation. If this be so, the author's implication that "we have here a very interesting point in connection with the much discussed question of the morphology of the paired limbs in vertebrates—a new and important corroboration of the lateral fold theory," can hardly be taken in the sense which would seem intended. There is, however, an alternative reading, to which he has himself pointed the way, which we are most readily inclined to adopt, viz. that already alluded to (*cf. antea*) as involving a comparison between the posterior pectoral lobe of Thelodus (*pc.*' Fig. 1) and the cornual flap of Cephalaspis which, with the author, we believe Lankester to have been right in regarding as "the equivalent of a pectoral fin." To put the case otherwise, we do not see the proof that the presumed forward extension of the fin-fold (*pc.*") is fin-like in structure, and we incline to the conclusion, especially in view of the perforation of its supposed investing plate by the so-called respiratory aperture in *Pteraspis* (1) that it is this alone which has been converted into the cornual plate of that genus and the postero-lateral plate of Drepanaspis; (2) that this is in all probability represented by the cornua of the Cephalaspidiæ, which may therefore well be accessory branchial organs probably enclosing a central passage —"atria," in fact, if not actual opercula! wherefore it would be interesting to ascertain whether they enclose a central canal or passage and are lined by shagreen-granules or tesseræ, as might well be if this interpretation is correct. And we further suggest as the natural sequence to this (3) that the posterior lobe of the supposed fin-fold of the Cœlolepidæ (*pc.*' Fig. 1) alone represents the pectoral member of the true fishes, and is in turn represented by the cornual flaps of the Cephalaspidians; and (4) that the pectoral member of the Pteraspidians has yet to be sought.

We put forward this view with all reserve, and we submit that while it is not opposed to the facts, it still further justifies the belief in a connection between the Cephalaspidian and Pteraspidian forms which Dr. Traquair has revived. All known facts of morphology justify the conclusion that the paired limbs of the vertebrate have been wholly evolved within that phylum, and there are not a few which suggest that the pectoral and pelvic members have been acquired independently in anterio-posterior succession. If so, may not the Cœlolepidæ and Cephalaspidiæ be now regarded (probably with the Pteraspidiæ as very distant allies) as the representatives of an apodal stage in evolution, at which the pelvic member had not yet come into existence. Their extreme structural simplicity and entire lack of jaws, teeth, and apparent endoskeleton capable of preservation in the fossil state, are certainly not at variance with this view, and under it the old belief in their extremely specialised nature and their presumed degeneration, towards which even Traquair himself inclines, with that in their affinity with the Marsipobranchs, largely disappears.

The question is one for the palæontologist; and while congratulating the officers of the Geological Survey and the Edinburgh Museum upon the addition to their already matchless collection of these wonderful remains, and the author upon the masterly manner in which, as a true morphologist, and with "soul," he has worked them out, we look to him and his friends in the field to furnish the next link in the chain. The present one is a triumph for all concerned, worthy the author of "The Palæoniscidæ" and interpreter of Palæospondylus, and as marking progress it is equal to anything achieved in the palæontology of the last two decades. G. B. H.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The following are among the lectures announced for the present term:—Prof. Clifton, acoustics; Mr. Walker, physical optics; Mr. Hilton, elementary mechanics and physics; Mr. Baynes, elementary heat and light; Mr. Jervis-Smith, dynamo and motor machinery and electrical testing; Prof.

Odling, silicon, boron and fluorine compounds; Mr. Fisher, inorganic chemistry; Mr. Watts, organic chemistry; Mr. Veley, physical chemistry; Mr. Marsh, the practice of organic chemistry; Mr. Vernon-Harcourt, the subjects of the preliminary examination; Mr. Elford, groups vi., vii., viii. in Mendeléef's periodic system; Mr. Elford, great chemists and their work; Mr. Walden, synthetical methods in organic chemistry, purin group, &c.; Mr. Wilderman, the velocity of reaction and equilibrium in homogeneous and heterogeneous systems; Prof. Sollas, history of the earth, Jurassic fossils; Mr. Dickson, the atmospheric circulation; Mr. Herbertson, river basins and shore lines; Prof. Miers, elementary crystallography; Mr. Bowman, some natural silicates; Prof. Weldon, general course of morphology, variation, inheritance, natural selection (continued); Mr. Goodrich, annelida; Mr. Jenkinson, elementary morphology; Mr. Günther, arthropoda (continued); Mr. Thompson, sauropsidan morphology, sauropsidan palæontology; Prof. Gotch, general course of physiology, physiology of the excitable tissues; Mr. Haldane and Mr. Ramsden, subjects of the Final Honour School; Mr. Burch, physiological physics; Prof. Vines, elementary course—botany; Prof. Tylor, anthropology in ancient literature; Mr. Stout, mental evolution; Prof. Case, psychology and the origin of knowledge.

CAMBRIDGE.—The Reader in Geography (Mr. Oldham) gives this term three courses of lectures, on the geography of Europe, on physical geography, and on the history of geographical discovery, respectively.

At Corpus Christi College, Mr. F. G. Channon, eighth wrangler, 1897, has been elected to a fellowship.

Mr. W. B. Hardy, Demonstrator of Physiology, has been awarded the Thurston Prize at Caius College, for his physiological researches.

The John Hopkinson memorial wing of the Cambridge University Engineering Laboratory will be opened on Friday, February 2, at 2.30. Lord Kelvin will deliver an opening address, after which the Master of Trinity will unveil a portrait of the late Dr. Hopkinson, presented to the Laboratory by subscribers.

WE learn from the *Athenæum* that by the will of a wealthy Africander, Dr. W. Hiddingh, the Cape University profits to the extent of 25,000*l.*, with a site for new university buildings, and 5000*l.* for the foundation of a scholarship. The South Africa College receives from the same source a legacy of 10,000*l.*

WE understand that the Berkeley fellowships at Owens College, referred to in a note last week (p. 284), were given only for a limited number of years by a generous friend of the College, and they have now ceased. There has never been an endowment upon which these fellowships were an annual charge.

A BILL "to authorise the regents of the Smithsonian Institution to confer certain degrees and for other purposes" has been introduced by the Chairman of the Senate Committee on the District of Columbia. *Science* publishes the following particulars of the provisions of the Bill:—That the regents of the Smithsonian Institution be authorised to appoint a board of five examiners, who shall, with the approval of the regents, prepare and publish a schedule of courses of studies preparatory to the degrees of master of arts, master of science, doctor of philosophy, and doctor of science. The examiners shall from time to time hold examinations in the City of Washington for the said degrees; and, on the satisfactory completion by any candidate of the prescribed course of studies for either of the above mentioned degrees, shall recommend such a candidate to the regents of the Smithsonian Institution for such degrees. The regents are hereby authorised to confer, under suitable regulations, the degrees above mentioned, and also the honorary degree of doctor of laws. Provided, That no person shall be accepted as a candidate for the degree of master of arts or of doctor of philosophy who has not completed a course of study at least equivalent to the course of study required of candidates for corresponding degrees in the most advanced universities in the United States; and provided further, That the degree of doctor of laws shall be conferred on no more than five persons in any one calendar year. The members of the board of examiners shall hold office during the pleasure of the regents of the Smithsonian Institution. Each examiner shall devote his entire time to the duties of instruction and examination assigned to him by the said regents, and shall receive a salary of 4000 dollars per annum, except that the chairman of the board shall receive a salary of 5000 dollars per annum.

THE inaugural lecture of the Department of Agriculture of the University of Cambridge, delivered by Prof. Somerville, has been published by the University Press. The subject is some aspects of the bearings of education and science on practical agriculture. Ten years ago very little was done for the education of the rural population in the principles of agricultural industries, but many agencies are now at work, and the assistance which science can give to agriculture is slowly being recognised by farmers. The establishment of a chair of agriculture at Cambridge, and its endowment for ten years, should serve to extend the movement for increased attention to agricultural interests in education. When the ten years provided for by the endowment have elapsed, it may confidently be expected that public opinion will see that the chair shall be placed upon a permanent footing. What has to be done between now and then is to show that farmers who use with intelligent discrimination the teachings of science have the best chance of success. Agricultural practice which neglects scientific results is doomed to failure, but if science is engrafted upon practice, it is possible for farmers to hold their own even in these years of depression. "It is the fortune of agriculture," remarks Prof. Somerville, "to be indebted to science at almost every turn. Zoology and physiology play their part in such directions as the breeding and feeding of live-stock, in the various ramifications of the veterinary art, and in the attractive section of economic entomology. Geology affects practical agriculture to a less extent, but no science adds more to the pleasures of a farmer's life. Mathematics and physics lend their assistance in such sections of a farmer's work as the calculation of volumes and areas, in draining, levelling, road-making, the use and maintenance of machinery, and the like." To this may be added that the agriculturist who has a knowledge of the principles of physical and natural science is better able to discern directions in which cultivation may be improved, and to take advantage of the results of agricultural research, than the farmer who does not possess such knowledge. Prof. Somerville's lecture should be widely distributed among agriculturists so as to correct the impression, still too common, that science is theory and that practice is independent of it.

SCIENTIFIC SERIALS.

American Journal of Science, January.—Products of the explosion of acetylene, by W. G. Mixter. The study of the explosion of acetylene was continued in order to obtain facts for or against the author's hypothesis that a sufficient frequency of molecular impacts is requisite to secure spread of explosive change throughout a gas. The experiments so far are not conclusive. Acetylene is always found after sparking and explosion. The author believes that it is not residual gas, but is formed by subsequent synthesis. This is supported by the fact that an endothermic compound of carbon and nitrogen is also formed in the eudiometer.—Glaciation of central Idaho, by G. H. Stone. The occurrence of wood in the esker gravels of Idaho suggests a comparison of that region with New England. The large valley ice sheets or Piedmont glaciers of north central Idaho formed a type intermediate in character between the more strictly local glaciers found further south and the great confluent ice sheet of British Columbia.—Graftonite, a new mineral, by S. L. Penfield. The mineral described is found on the south side of Melvin Mountain, about five miles west of the village of Grafton, New Hampshire. It is an iron-manganese phosphate closely analogous to triphylite, with which it is found intergrown.—Explorations of the *Albatross* in the Pacific Ocean, by Alexander Agassiz (see p. 211).—Constitution of the ammonium-magnesium arseniate of analysis, by Martha Austin. When ammoniacal magnesia mixture in slight excess is added to the faintly acid solution of arsenic acid (carrying no ammonium salts) in a volume not exceeding 200 c.c., the precipitate appears to fall in ideal condition.

Symons's Monthly Meteorological Magazine, January.—Low barometric pressure on December 29, 1899. The notes refer to the readings along the remarkable course of the storm, which took first an easterly track along the south of Ireland, and then suddenly changed it to a northerly one over the Isle of Man.

The minimum seems to have been about 28·1 inches; at Camden Square, London, where the lowest reading was 28·247 inches. The only lower readings there since 1858 have been: 28·332 inches on January 24, 1872; 28·364 inches on December 4, 1876; and 28·295 inches on December 9, 1886.—Severe frost in December 1899. A table shows the number of shade minima below 15°. Near Hereford a temperature of −2° was recorded on the 15th in a screen of the Stevenson pattern. At Lyme Regis, Dorset, a correspondent writes that some soda-water bottles which were opened on the golf links all instantly froze; before being opened they were perfectly fluid and free from ice.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 7, 1899.—"*Polytremacis* and the Ancestry of the Helioporidæ." By J. W. Gregory, D.Sc. Communicated by Prof. Lankester, F.R.S.

The recent blue coral *Heliopora* presents striking resemblances in structure to the palæozoic *Heliolites*. All the earlier writers on corals accordingly regarded the two genera as intimately allied. But some later authorities consider the resemblances as accidental, and that the corals have no special affinities. Thus, according to F. Bernard, *Heliopora* and *Heliolites* belong to distinct subphyla. Lindström admits only one species of *Heliopora*, and regards the genus as quite isolated, as essentially distinct in structure from *Heliolites*, and as further separated from the latter by "the total absence of all connecting links from the end of the middle Devonian to the recent times." The author, however, considers that the original view of the close affinity of *Heliopora* and *Heliolites* is correct, that the two genera are essentially similar in structure, and that they are linked by a series of eocene and cretaceous corals. Amongst these fossils is the genus *Polytremacis*, which is redescribed, and a new species of *Heliopora* from the cretaceous of Somaliland. It is suggested that *Heliopora* has descended from the palæozoic Heliolitidæ by degeneration in size and increase in number of the cœnenchymal cæca.

"On the Association of Attributes in Statistics, with Examples from the Material of the Childhood Society, &c." By G. Udny Yule. Communicated by Karl Pearson, F.R.S.

Geological Society, January 10.—W. Whitaker, F.R.S., President, in the chair.—On a particular form of surface, the result of glacial and subaërial erosion, seen on Loch Lochy and elsewhere, by Dr. W. T. Blanford, F.R.S. This form of surface, first noticed by the author on Lake Como, was afterwards observed in the Great Glen of Scotland and in British Columbia. It consists of an almost even plane sloping at a moderate or high angle, and cut at intervals by small ravines or channels. The sides of the Great Glen have been planed by glacier-action to a greater extent than usual, and between Loch Lochy and Loch Oich, near Laggan, the sides of the Glen have a regular and flat slope of over 35° up to about 1000 feet above sea-level. Numerous stream-cut channels draining down this slope are, on an average, not more than 10 to 15 feet deep, but some quite exceptional examples may be 50 feet deep; these channels occupy less than a fourth of the surface. In addition there are larger glens which, although they run out into shallow ravines where they cut the sloping side of the Great Glen, are frequently 500 feet in depth among the hills. If these were ordinary stream-valleys before the Glacial Period, the cutting away of the ridges separating them to the extent of at least 250 or 300 feet must be attributed to glacial erosion on the sides of the Great Glen. The erosion of the small ravines in the glacial slope must have been effected by streams in post-Glacial times, and the measurement of their rate of erosion might be expected to throw light on the amount of time which has elapsed since the Glacial Period in this district. "The general effect produced by the whole evidence is . . . the small amount of denudation that has taken place since the Great Ice Age, and the necessary deduction that no great period of time, measured in years, can have elapsed between the Glacial Epoch and the present day."—On the geology of Northern Anglesey (Part II.), by C. A. Matley.—The formation of dendrites, by A. Octavius Watkins. If two plane-surfaces be separated by a film of suitable plastic material, and one surface be rotated slowly on the other through a small arc, the plastic material collects into branching forms similar to the structure of dendrites. The dendritic form starts from the part farthest from the axis, and the flow of material is from the smaller to the larger branches, the smaller uniting to form the larger. The author explains dendritic structure by the formation of a fissure in rock which becomes filled with a thin film of dendritic material; if the fissure is slowly widened, the dendrite starts where the widening commences, coinciding dendrites being formed on each wall.

Royal Meteorological Society, January 17.—Annual Meeting.—Mr. F. C. Bayard, President, in the chair.—In his presidential address, Mr. Bayard discussed the meteorological observations made at the Royal Observatory, Greenwich, during the fifty-one years 1848–1898, and brought out in a novel way many interesting features in the variability of the various observations of the barometer, maximum and minimum temperatures, relative humidity, direction of the wind and rainfall. These were shown in a diagrammatic form on the screen by means of a number of lantern slides. The address was also illustrated by various views of the Royal Observatory and of the instruments employed.—Mr. G. J. Symons, F.R.S., was elected President for the ensuing year.

PARIS.

Academy of Sciences, January 15.—M. Maurice Lévy in the chair.—On the distribution of the abnormal residues of a function, by M. H. Padé.—On the reduction of an algebraical problem, by M. J. Ptaszycki.—Determination of the invariants attached to the group G_{168} of M. Klein, by M. A. Boulanger.—Vector fields and fields of force. Reciprocal action of scalar and vectorial masses.—Localised energy, by M. André Broca.—On the distribution of potential in a heterogeneous medium, by M. A. A. Petrovsky.—On the co-volume in the characteristic equation of fluids, by M. Daniel Berthelot. A comparison of the experimental isotherms for carbon bisulphide, ethyl chloride, carbon dioxide and ethylene with various modifications of the Van der Waals formula. If the co-volume b be regarded as a function of the temperature, the Van der Waals equation can be made to represent well the liquid state. The formula proposed by the author is $b_T = b_c\left[1 + 0{\cdot}3\left(\frac{T}{T_c} - 1\right)\right]$, where b_T is the co-volume at T, b_c that at the critical temperature, T_c.—On the mechanism of hearing, by M. Firmin Larroque. For a simple sound, whether the wave phases are concordant or not, the centre of perception receives two transmitted impressions together, there being no interference in any case. For two simple or complex sounds, two corresponding impressions are received by the centre of perception, there being neither beats nor resultants, the two ears being acoustically distinct.—The permanent modifications of metallic wires and the variation of their electrical resistance, by M. H. Chevallier. If the resistance of a wire is R at a temperature T_0, then heated to T, and again measured at T_0, in general, the resistance R′ last measured will be different from R. The phenomenon appears to be due to a tempering effect, and is most clearly marked with metals and alloys that have not been hardened. The effect is very marked with ordinary platinum-silver wire.—On the Hall phenomenon and thermomagnetic currents, by M. G. Moureau. The thermomagnetic currents discovered by Nernst and Ettingshausen in 1886 to exist in a thin metallic plate placed in a magnetic field normally to the lines of force and traversed by a heat current. Several attempts have been made to explain these phenomena, by hypotheses resting upon numerous arbitrary assumptions. The author now shows that these results are an immediate consequence of the Hall effect, the values calculated from this point of view agreeing extremely well with the experimental numbers, except in the cases of nickel and cobalt, which require further investigation.—On the discharge of electrified bodies and the formation of ozone, by M. P. Villard. The author concludes from his experiments that in ordinary air incandescent bodies may emit kathode rays comparable to the Lénard rays, but of very low voltage. If this is the case, several distinct phenomena can be explained; the power of discharging electrified bodies possessed by flame, incandescent bodies and phosphorus; the discharge by ultra-violet light, the production of ozone by flames, incandescent bodies, oxidation of phosphorus, electric sparks, and by radium.—On a method of measuring the velocity of the Röntgen rays, by M. Bernard Brunhes. The ordinary methods of measuring the velocity of light cannot be used with the X-rays since they are not reflected, but by applying the discovery of M.

Swyngedauw of the effect of the X-rays upon the discharge of bodies just below their ordinary sparking potential, it has proved to be possible to obtain comparative measurements of the velocity, which would appear to be of the same order as ultra-violet light.—On the nature of white light and the X-rays, by M. E. Carvallo.—The numerical laws of chemical equilibrium, by M. O. Boudouard. The formula of Le Chatelier is applied to the reaction $CO_2 + C \rightleftarrows 2CO_2$, and the composition of the gas mixture calculated for temperatures between 450° C. and 1050° C.—On the electrolysis of potassium chloride, by M. A. Brochet. The yield of chlorate is considerably increased by the presence of a little potassium bichromate in the solution. Curves are given showing the amounts of chlorine present as hypochlorite, chloride, and chlorate after a varying number of ampère hours.—On a new crystallised molybdenum sulphide, by M. Marcel Guichard. By heating molybdenum bisulphide in the electric furnace a lower sulphide, Mo_2S_3, is produced, which can be obtained as long steel-grey needles from the melted mass by treatment with aqua regia. Heated to a red heat in sulphur vapour the bisulphide is reformed; at higher temperatures it is dissociated into sulphur and molybdenum.—The action of magnesium upon saline solutions, by M. Henri Mouraour.—Automatism of the nerve cells, by M. Pompilian. Curves are given for the automatic movements observed in *Dytiscus Marginalis*. The author concludes that nerve cells are constantly disengaging nervous energy, without any excitement being required, and hence that nervous activity is really automatic, although varying in intensity with time. The higher nervous centres under normal conditions exert a controlling influence over the lower centres, the activity of the latter being clearly shown when the former are removed. Hence it would appear in pathology that the tremors may be explained either by a diminution of the controlling power exercised by the higher cerebral centres upon the lower medullary centres, or by an increase of activity of the latter.—On a category of crystalline groups escaping optical investigations, by M. Fred. Wallerant. In general, in a crystalline grouping, the different crystals can be easily distinguished, their ellipsoids of optical activity having different orientations. If, however, the orientation of the crystals are symmetrical with respect to the elements of symmetry of this ellipsoid, it will be impossible to distinguish them by polarised light. Cumenglite and chiastolite are considered as examples.—On the denudation of the central plateau of Haye, or Forêt de Haye, by M. Bleicher.—On the presence of the Upper Eocene in Tunis, by M. Flick.

DIARY OF SOCIETIES.

THURSDAY, JANUARY 25.

ROYAL SOCIETY, at 4.30.—Mathematical Contributions to the Theory of Evolution—On the Law of Reversion: Prof. K. Pearson, F.R.S.—(1) On the Mechanism of Gelation in Reversible Colloidal Systems: (2) A Preliminary Investigation of the Conditions which determine the Stability of Irreversible Hydrosols: W. B. Hardy.—On the Effects of Strain on the Thermo-electric Qualities of Metals, Part II.: Dr. M^{c} Maclean.—On the Periodicity in the Electric *Touch* of Chemical Elements. Preliminary Notice: Prof. J. C. Bose.

ROYAL INSTITUTION, at 3.—The Senses of Primitive Man: Dr. W. H. R. Rivers.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Adjourned Discussion on the Report of the Institution's Visit to Switzerland.—*And if time permit:* An Electrolytic Centrifugal Process for the Production of Copper Tubes: Sherard Cowper-Coles.

FRIDAY, JANUARY 26.

ROYAL INSTITUTION, at 9.—Motive Power, High Speed Navigation, Steam Turbines: Hon. C. A. Parsons, F.R.S.

PHYSICAL SOCIETY, at 5.—Some Developments in the Use of Price's Guard Wire in Insulation Tests: Prof. Ayrton and Mr. Mather.—Reflection and Transmission of Electric Waves along Wires: Dr. E. Barton and Mr. L. Lownds.—The Frequency of the Transverse Vibrations of a Stretched India-rubber Cord: T. J. Barker.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Water Meters of the Present Day, with special reference to Small Flows and Waste in Dribbles: William Schönheyder.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Simplon Tunnel: C. B. Fox.

SATURDAY, JANUARY 27.

MATHEMATICAL ASSOCIATION (University College, Gower Street, W.C.), at 2.—Dynamical Applications of the Theory of Correspondence: Sir Robert S. Ball.—Triangles Triply in Perspective: J. A. Third.—The Teaching of Indices and Surds: Prof. R. W. Genese.—Illustrations of Porismatic Equations: T. J. Bromwich.—A Note on the Focoids: R. F. Davis.

ESSEX FIELD CLUB, at 3.—Visit to Museum of College of Surgeons. Conductor: Prof. C. Stewart, F.R.S.

MONDAY, JANUARY 29.

SOCIETY OF ARTS, at 8.—The Nature and Yield of Metalliferous Deposits: Bennett H. Brough.

INSTITUTE OF ACTUARIES, at 5.30.—Increasing Reversionary Charges: W. B. Paterson

TUESDAY, JANUARY 30.

ROYAL INSTITUTION, at 3.—Structure and Classification of Fishes: Prof. E. Ray Lankester, F.R.S.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—Anniversary Meeting.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Steamers for Winter Navigation and Ice-breaking: Robert Runeberg.

WEDNESDAY, JANUARY 31.

SOCIETY OF ARTS, at 8.—The Undeveloped Resources of the Bolivian Andes: Sir W. Martin Conway.

THURSDAY, FEBRUARY 1.

ROYAL SOCIETY, at 4.30.—*Probable Papers:* A Case of Monochromatic Vision: Sir W. de W. Abney, F.R.S.—Thermal Radiation in Absolute Measure: Dr. Bottomley, F.R.S., and Dr. Beattie.—Electrical Conductivity in Gases traversed by Kathode Rays: Dr. McLennan.

ROYAL INSTITUTION, at 3.—The Senses of Primitive Man: Dr. W. H. R. Rivers.

LINNEAN SOCIETY, at 8.—On Botanic Nomenclature: C. B. Clarke, F.R.S.—On the Zoological Results of an Expedition to Mount Roraima, in British Guiana, undertaken by Messrs. F. V. McConnell and J. J. Quelch: Prof. E. Ray Lankester, F.R.S.

CHEMICAL SOCIETY, at 8.—The Chlorine Derivatives of Pyridine. Part V. Synthesis of aa'-Dichlorpyridine. Constitution of Citrazinic Acid: W. J. Sell and F. W. Dootson.—The Formation of Heterocylic Compounds: S. Ruhemann and H. E. Stapleton.—The Space Configuration of Quadrivalent Sulphur Derivatives: Methyl Ethyl Thetine Dextrocamphorsulphonate, and Dextrobromocamphorsulphonate: W. J. Pope and S. J. Peachey.—Nitrocamphane: M. O. Forster.

RÖNTGEN SOCIETY, at 8.—Röntgen Rays in Diseases of the Chest: Dr. Hugh Walsham.—Mr. A. Hastings Stewart will show a small Egyptian Mummy and Skiagrams of the same.

FRIDAY, FEBRUARY 2.

ROYAL INSTITUTION, at 9.—Wireless Telegraphy: G. Marconi.

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