THURSDAY, MAY 18, 1893.

OSTWALD'S GENERAL CHEMISTRY.

Lehrbuch der Allgemeinen Chemie. Von Dr. Wilhelm Ostwald. Band I. 1891, Band II. Theil I. 1893. Zweite Auflage. (Leipzig : Wilhelm Englemann.)

THE conception of molecule is essential in explaining the phenomena of both chemistry and physics. Porosity and compressibility point to the conclusion that matter does not entirely fill space, to account for the dispersion of light requires that matter should have a grained structure; these and countless other physical facts find an explanation in the conception of molecule. Moreover, from various observations, more especially on the properties of gases and the phenomena of surface tension, the size of molecules can be approximately calculated, and in terms of the idea of molecule deduced in ways such as these physical properties are explained.

The chemist, on the other hand, has arrived at the need of the conception of molecule from totally different considerations. In the early days of his science, when the laws of combining proportions and of chemical equivalents were taking definite shape, the revival of the conception of atom was of immediate service in furthering the progress of chemistry. It was not long in becoming apparent, however, that the conception of atom alone was insufficient to meet the facts.

The relative numbers of atoms entering into the composition of compounds was a matter of doubt until Avogadro's hypothesis was accepted, and until it was granted that definite groups of atoms—chemical molecules— were concerned in chemical processes.

The chemist has thus built up his conception of molecule in accordance with chemical facts; he regards it as a structure composed of parts, and in order to explain the existence of isomers, he has to assume definite relative arrangements of the atoms within a molecule.

From the fact that the two conceptions of molecule have been derived independently of one another, it has come about that physical properties are discussed more or less apart from the chemical nature of the substances examined, and for this reason within recent times there has arisen a fascinating field of inquiry on the borderland of chemistry and physics. For it has been urged, "Is it not possible to trace the cause of physical phenomena beyond the physical molecule?" If, as the chemist has shown, the molecule is a structure composed of parts, is it not possible that these parts of molecules are the units to be dealt with? In short, "Is not the ultimate cause of physical as well as of chemical phenomena to be ascribed to the chemical atoms and their mutual relationships?"

Already this question has been answered in several ways, and in none more striking than by those investigations which are concerned with the physical constants of substances and their chemical nature. Here it has been shown that the magnitudes of many physical constants are conditioned by the nature, number, and arrangement of the atoms which compose molecules and that frequently definite changes in chemical nature bring about definite quantitative changes in the magnitude of physical constants.

Books dealing with such investigations as these are but few, indeed the first volume of the book before us is practically the only one which gives a comprehensive view of what has been done in this direction. If we exclude those parts which are purely physical and which are concerned with familiarising the reader with the physical properties to be treated, the volume may in the main be taken as linking on the chemical to the physical conception of molecule, in so far as to show that the magnitudes of physical constants are functions of molecular weight and molecular structure.

The general arrangement of the contents of this volume is pretty much as it was in the previous edition, although very few pages remain as they were, and the introduction of recent investigations has increased the size of the volume by about one-third. The atomic hypothesis and the laws upon which it is based are first treated, then follows a useful summary of the various atomic weight estimations, from which are deduced the probable values of those fundamental constants, values which are already finding their way into current literature. The numerical relations existing between the atomic weights of the elements constitute the concluding portion of this the first of the six books into which vol. i. is divided. Succeeding books deal respectively with the physical properties of gases, liquids, solutions, and solids, and with the relations existing between the physical properties and the chemical nature of the substances.

Solutions are, in this edition, for the first time treated in a separate book, which with certain additions has been translated into English by Mr. Pattison Muir, and has already been noticed in these columns (NATURE, vol. xlv. p. 193). Electric conductivity and electrolysis now find a place in vol. ii. under electro-chemistry. The sixth and last book of vol. i. deals with chemical systematics—the criteria by which atomic weights are chosen, the periodic law and the relations between the physical constants of the elements and their atomic weights, and the molecular theory and the structure of chemical compounds in which the doctrines of valency, isomerism, &c., are discussed.

The peculiar interest which attaches to connections between the physical constants of substances and their chemical nature lies in the fact that an idea is thereby obtained of the constitution of the substances as they actually exist. Structure as deduced from purely chemical methods is founded upon reaction. The compound has to be decomposed before its constitution can be determined, and occasionally such methods lead to ambiguous results. Examples are steadily multiplying of compounds which in one reaction appear to correspond with one formula, while in another reaction a different formula better represents their chemical behaviour. Already measurements of physical constants have been applied to some such cases and have served to indicate that the structure of a pure substance may be conditioned by its temperature. At high temperatures, for example, acetyl acetone would appear to exist in the ketonic condition, $CH_3CO.CH_2.CO.CH_3$, while as temperature falls it would seem as if a gradual transition to the alcoholic conditions,

$CH_3.C(OH):CH.CO.CH_3$ and $CH_3.C(OH):C.C(OH)CH_3$, took place.

But physical methods can be applied to the study of the phenomena of chemical change as well as to those of chemical structure. Change of any kind taking place in material substances is to be sought in the nature of the energy associated with those substances, and chemical change has therefore to be sought in the nature of chemical energy. Of the nature of chemical energy, however, we know but little. Although it is the source of most of the energy turned to practical account in the arts and manufactures, and indeed, directly or indirectly, of all vital energy, it cannot be directly measured, and its nature is, as yet, but a matter for speculation.

Part I of vol. ii. of the "Lehrbuch" is concerned with making clear the present position of knowledge on this subject of chemical energy. To begin with, energy in general is discussed, the various forms under which it is known to us, and the units in which they are measured. Particular attention is directed to the factors which enter into the expressions denoting several of the types of energy, and more especially to the intensity factor. In the case of heat, for example, the intensity factor is temperature, and temperature, of course, determines whether heat energy shall be transferred from one body to another. A heat change between two bodies is conditioned by their temperature, and if the factors entering into the expression for chemical energy could be ascertained, the cause of chemical change might be traced in a similar way.

But although chemical energy cannot be directly measured, it can be transformed into other kinds of energy, and in turn other kinds of energy may pass into chemical energy. The amounts of these other kinds of energy which are thus involved in chemical processes are often capable of accurate measurement, and from such measurements alone can an insight into the nature of chemical energy be at present obtained. With such measurements the rest of the part is concerned.

During chemical change, chemical energy passes most readily and most completely into heat, and hence thermochemistry is first dealt with. A general historical discussion of the subject is succeeded by chapters on the non-metals, salt formation in aqueous solutions, the metals, and organic compounds. The concluding chapters deal with the "energetics" of heat, wherein is to be found the material which can be grouped around the second law of thermodynamics and the nature of heat energy in general, and with "chemical energetics" which treats of such attempts as have been made to arrive at the nature of chemical energy and its relations to heat energy. Where possible, connections between the chemical nature of substances and the heat energy to which they give rise during chemical change are pointed out, and the general application of thermal results to problems in chemical structure is kept well to the front.

The subject of electro-chemistry, which has been entirely recast, now occupies some 500 pages, as compared with little more than 100 in the first edition. It consists of a historical introduction, and of chapters on electrical energetics, Faraday's law, the migration of the ions, the conductivity of electrolytes, the constitution of electrolytes and the properties of ions, electromotive force, the differences of potential in cells, and on electrolysis and polarisation. In this section the author has collected and generalised the mass of communications which have recently been brought into existence by the fruitful hypothesis of electrolytic dissociation, and has connected them up with previous knowledge on the electrical properties of solutions. In conjunction with other portions of the "Lehrbuch" on the stoichiometry of solutions, this section gives the only full and systematic account of the new theory of solutions which is available to the general reader.

The third and last book of this part takes up the subject of photo-chemistry. The nature of radiant energy, which plays so important a part in the economy of nature and its relations to chemical energy, are first discussed. Then follow chapters on actinometry, the law of photochemical action, and on special photo-chemistry, which deals with the assimilation of carbon by plants, and the action of light on various chemical substances.

Enough has been stated to show that the work is unique. There is no other book which even attempts to cover the same ground. No chemical library can be regarded as complete without a copy of Ostwald's "Lehrbuch." It contains an enormous amount of information, both theoretical and practical, which is simply indispensable to the chemist and to the physicist. It is, indeed, difficult to overestimate the value of such a work.

But at the same time, mainly for the reason that it touches upon so many subjects, its usefulness in certain directions may to some extent be interfered with. One cannot fail to notice that the character of the work frequently savours more of a dictionary than a handbook. In the chapters on solutions and electro-chemistry there is, perhaps, not much room for this objection, for there the author has a definite purpose in view—the elucidation of the "new theory"—and writes around it, moulding his information and shaping the issues in a way that leaves little to be desired, if his standpoint be granted. Contrasted with the treatment of these sections we have, on the other hand, that of the book generally. Here are set out short abstracts, in many cases but fragmentary, of the more important researches on the subject under discussion, but little attention being paid however to generalising the results or smoothing down the discrepancies, or indeed the contradictions which occasionally arise. For example, under the subject of the molecular volumes of liquids Kopp's work comes first, and his method of obtaining atomic volumes is given, the values of carbon and hydrogen being derived by the comparison of aromatic and fatty compounds. In due course Horstmann's conclusion that the ring-grouping of atoms exerts a marked effect on molecular volume finds a place, and the author passes on to other researches. But if Horstmann's conclusion is justified the whole superstructure of Kopp's calculated atomic volumes is subject to modification, as the effect of ring-grouping is ignored in the derivation of his atomic constants. Again, here as elsewhere, the author gives Schröder's work the prominence which has been more or less denied it in the past. Schröder's method, however, involves different atomic constants to those of Kopp, and it is left almost entirely to the reader to assess the relative worth of the two systems. On one page of this chapter, too, Schiff's rule relating to the boiling points and molecular volumes of isomers is given, while two pages later are set out the results of Städel, which lead to the opposite conclusion, a conclusion which is much more generally true than that of Schiff, as the reader may verify by referring to the tables of physical constants given towards the end of the chapter.

The author may purposely have left matters in this condition, his idea being merely to indicate the gist of what has been done on the different questions. Indeed the present condition of subjects like molecular volume is so unsatisfactory as to prevent any very definite conclusions being stated. Nevertheless, if such abstracts as are given had on various occasions been supplemented by a statement of opinion as to the nett upshot of the whole discussion, there is little question that the average student would have found the mastering of several portions of the "Lehrbuch" a task of less difficulty than at present it is.

On p. 387, lines 2, etc., a volume-change due to oxygen is attributed to hydrogen: typographical errors are somewhat numerous, as could hardly be otherwise in a work of this kind.

To complete the second edition of the "Lehrbuch," Part 2 of the second volume, which treats of chemical affinity, has still to be published. Its appearance will serve to complete a work which goes further than any other to show how chemistry and physics must be united in the endeavour to arrive at the real nature of material phenomena. J. W. RODGER.

CLARK ON THE STEAM ENGINE.

The Steam Engine: a Treatise on Steam Engines and Boilers. By Daniel Kinnear Clark, M.Inst.C.E. (London, Glasgow, Edinburgh and New York: Blackie and Sons, Limited, 1892.)

THE author of this book holds the first place among those who many years ago made the locomotive an object of scientific study. His famous work on railway machinery is still of prime importance, holding as it does an honoured place in many drawing offices. The present work consists of two ponderous volumes of some 800 pages each, and claims to be a comprehensive, accurate, and clearly written text-book, fully abreast of all the recent developments in the principle, performance, and construction of the steam engine. This no doubt is a very large claim to make for any work, but when one remembers who the author is, one is bound to admit that no one is more capable of carrying out so important a scheme.

Besides the author's many researches in locomotive engineering particularly, we notice that the numerous published records of investigation and practice have been made use of. This is certainly as it should be, and having been judiciously done adds greatly to the value of the work as a book for reference.

The work is divided into four main sections:—(1) The principles and performance of steam boilers; (2) the principles and performance of steam engines; (3) the construction of steam boilers; (4) the construction of steam engines. These main sections are again subdivided into many chapters.

The vast amount of information to be gathered from these pages may be imagined when it is noted that the first section alone takes up some 373 pages. Most of this space is absorbed by descriptions of experiments with special types of boilers, mechanical and other means of stoking, the prevention of smoke and the relative efficiency of various kinds of coal. Besides this the properties of steam are discussed, and the question of the economical combustion of fuel is very thoroughly gone into. The second section is an excellent treatise on the general behaviour of steam in the cylinder, and here we find evidence of the great experience of the author in this subject, particularly in the handling of the indicator diagram and the many lessons to be learnt from it when properly understood. The third section deals with the construction of steam boilers and concludes the first volume. Here we find a collection of reports and original matter of a valuable description embracing the whole subject. It is a pity that the classical researches of the late Mr. P. W. Willans find no place in the volume, because he, of all engineers, studied the thermodynamics of steam thoroughly, and his contributions to science on this subject are invaluable. It may be noted that his central valve high-speed engines find no place in the work. This also is to be regretted, because this type of engine is rapidly coming to the front, both as an economical machine and a trustworthy motor particularly for electric lighting by direct driving, the Glasgow Corporation Electric Lighting Station being among the latest to be fitted with these engines.

The first volume may be roughly said to contain most of the theoretical part of the subject, and the second volume the description of many types of stationary, marine, and locomotive engines. This volume begins with a very complete description of the various valve gears in use and the distribution of steam by ordinary and other slide valves, also the construction and modes of working of the many governors in use. Further on stationary engines for general purposes are described and very fully illustrated. We miss from these excellent examples the many types of high-speed engines used for driving dynamos, centrifugal pumps, fans, &c. Many of these have reached a high state of efficiency and might have been included with advantage.

Chapter lx. deals with British and foreign types of locomotives. We are not surprised to find that the many chapters on the locomotive are by far the best in the whole work. The author may be said to have grown up with the locomotive and to have made it his own particular study; to this day the plucky man who rode on the buffer beams of the old Edinburgh and Glasgow four-wheeled engines taking indicator diagrams is often quoted on that line, now part of the North British system.

The paper read by the late Mr. William Stroudley on the construction of locomotive engines, &c., before the Institution of Civil Engineers contains probably the most recent and trustworthy information at present available on this subject. The author has done well in making the quotations he does from this source. Of the British locomotives illustrated all are of most recent design. The table of types of American engines made by the Baldwin locomotive works is interesting, and the illustrations are good; but what is the use of giving the reputed weight of trains hauled without quoting the average speed? Surely the one can be of little service without the other. Continental locomotive practice is well represented in the types in use on the St. Gothard railway. Of peculiar types of locomotives perhaps the six-coupled double bogie Fairlie engine is a good example. This engine, designed by Sir Alexander M. Rendel for the Mexican Railway Company, is stated to be able to haul a train weight of 3600 tons on the level. The engine when fully charged carries 2850 gallons of water, and has 300 cubic feet of room for coal, and weighs 92¼ tons. On regular duty the engines run on a section of road which, for a length of fourteen miles, has many gradients of 1 in 25, with curves of 350 feet radius. More recent Fairlie engines supplied to this company weigh 93 tons 16 cwt. in running order, and are reported to do their work admirably.

We now come to the description of the different types of compound locomotives in use. These are practically all included in the Webb and Worsdell types in use in this country. Of the Webb type we find the Dreadnought class, and, in the appendix, the Greater Britain, thoroughly described and well illustrated.

At the present time the London and North-Western Railway Company have eighty-three compound locomotives of Mr. Webb's design at work, the total mileage of which since 1882 up to the end of December, 1892, was 22,854,037 miles, with an average consumption of 35·1 lbs. of coal per mile. This includes not only the fuel consumed in actually working the train, but also 1·2 lbs. used in raising steam and all fuel consumed whilst the engine is standing or shunting. The description of the Worsdell type of compound is equally clear, and is well illustrated by the Great Eastern and North Eastern locomotives. Why, however, are the Worsdell intercepting and starting valves alone described and illustrated? when this type of valve is seldom if ever used outside the North-Eastern Railway, the Worsdell Von Borries, Lapage, disc automatic valve being generally adopted in its place. Sixty Worsdell compound goods engines of the Mogul type have recently been sent to India, the cylinders being respectively 20 inches and 28 inches in diameter, stroke 26 inches, and the coupled wheels 5 feet 1½ inches in diameter. These engines and tenders weigh about 95 tons in running conditions.

In the addenda to the second volume there is some interesting information in reference to the construction of American locomotives and boilers, and details are freely illustrated. Following this is a description of the Vauclain compound locomotive as made by the Baldwin locomotive works. Then comes a short description of the Westinghouse brake—a very good break no doubt; but why should not the Vacuum brake find a place in the volume?

These volumes cannot of course be appreciated without careful study. They are a perfect mine of information, partly original, partly derived from contributions to the proceedings of various technical institutions and societies. The illustrations are excellent, and the typography remarkably clear. The work should be welcomed, both by the student and the engineer, as the best text-book on the steam engine and boiler yet published.

N. J. LOCKYER.

A LIFE OF LOUIS AGASSIZ.

Louis Agassiz: his Life and Work. By Charles Frederick Holder, LL.D., &c. (Leaders in Science.) (G. Putnam's Sons, New York and London.)

WITHOUT a Life of Louis Agassiz a series of histories of leaders in science would be incomplete. Fortunately materials are not lacking, for in addition to the "Life and Correspondence" edited by his widow, there are numerous sketches and accounts of particular aspects of the man. The present volume tells the main incidents of his life and work, pleasantly and succinctly, and presents us with a clear outline of a remarkable personality. The book is well printed and the illustrations are not few. Some are good, others are not specially connected with the text, two are failures. Both relate to Switzerland. One is a sensational picture of Agassiz' "descent into the heart of a glacier," where he is being lowered down into a crevasse, while the text clearly shows that he descended a *moulin*. The other represents "Agassiz on the pinnacle of the Jungfrau." We think that this must be a studio composition, for the "pinnacle" is not very like what we have seen, and the topography of the view is incomprehensible.

Agassiz was a sturdy Swiss lad, uniting, as became a Neuchâtelois, something of French versatility with German tenacity of purpose; a close and keen observer delighting in every aspect of nature, happily neither "crammed" nor forced as a boy. When only twelve years old he was an omnivorous collector, and was more than this, a close student of his treasures.

Intended for commerce, he prevailed upon his parents to let him attend a course of classes at the University of Lausanne, then to proceed to Heidelberg and Munich as a student of medicine. At the age of twenty-three he had obtained the degree of doctor in that faculty as well as in philosophy. By this time, however, he had determined to devote himself to science, having already made his mark by his work on fresh-water fishes. After some stay in Paris a professorship was ultimately created for him at Neuchâtel, which he held until a visit to America ended in his accepting a post at Cambridge, Massachusetts, and settling down in the United States. But before leaving his native land he had become famous also by his studies of glaciers; still it was in the New World that the most important part of his life's work was done. Apart from the immense impulse which he gave to the progress of science in the United States, his explorations along the coast of Florida, in Brazil, on both coasts of South America, all supplied abundant material for study, which was worked up with unflagging industry.

The book, in short, is a marvellous record of work accomplished. We read in it of incessant labours in the lecture-room, the laboratory, and the field, yet the list of his books and scientific papers appended to this volume is perfectly appalling. Of the former there are thirty-nine, large and small; the list of the latter occupies twenty-two and a-half pages, each containing about ten entries, on the average. But this incessant activity, mental and physical, wore out even the sturdy Switzer, careful as he had always been in exercising the body. Cuvier's last words to him, "Be careful, and remember that work kills," had been, perhaps of necessity, neglected. The day after they were spoken the great naturalist had been stricken to death by paralysis. They were equally prophetic in the case of Agassiz, for by his sixty-seventh year even his vigorous constitution was worn out.

Agassiz was a born teacher. As one of his admirers says, "His greatest work in science was his influence upon other men." Surely this is one of the best of epitaphs. This memoir contains some pithy sayings worth remembering in our generation. These are a few samples—"It is a false idea to suppose that anybody is competent to learn or to teach anything;" "The mind is made strong not through much learning but by the thorough possession of something;" "Learn to read the book of Nature for yourself;" "Train your pupils to be observers;" "It is better to have a few forms well known than to teach a little about many hundred species;" "The study of Nature is an intercourse with the highest mind." A remark, also of his, has a lesson for this age of many books, when he said, commenting on his early difficulties in obtaining them, that "he believed it had been really an advantage, for it prevented him from relying too much on them, their absence forcing him to investigate for himself."

Dr. Holder compares the influence of Agassiz in America with that of Darwin in England. It was in many respects very different, as were the men; yet they had much in common: the same intense love of nature, the same thirst for knowledge, the same indomitable energy in the pursuit of it. They were alike in being seriously hampered: Agassiz by poverty, at any rate in the earlier part of his life, for many a time his mind had to be fed at the expense of his body; Darwin by ill health in the larger and later part. Yet they were very different: the one in constant intercourse with his fellow men, the enthusiastic leader of a band of students, the centre of a society; the other compelled to lead a recluse life. They looked also upon nature from different standpoints. Agassiz was unable to accept Darwin's views as to the origin of species, though it is curious to see what concessions he was prepared to make in regard to a progression from an embryonic stage to one of high development. This, however, must be by successive creations, not by evolution. In regard to the latter he apparently shared the fears of not a few other religious men, and failed to see that the vision of Mother Carey in Peacepool, "making things make themselves," may be as full an expression of the operation of a Divine Mind as any scheme of creation.

Agassiz, though he had a hard struggle, was fortunate in many respects: in the possession of good parents, a vigorous frame, and a sound constitution; above all, in acquiring the friendship of such men as Cuvier and Humboldt at the age when their help was most needed. He was happy, like Darwin, in his family life, with a wife who was a helpmate, and a son who followed his footsteps, and still does honour to the name. Like Darwin also, he was *felix opportunitate vitæ et mortis*. Both had their obstacles to overcome, and their difficulties to conquer, but they would have found these more formidable, because more insidious, in the present generation. Is an Agassiz or a Darwin any longer a possible product? Natural science is now sometimes in danger of becoming a department of literature or a branch of physics. These men went to nature for their teaching rather than to books: now they would find it hard to avoid being smothered with "the literature of the subject," and being choked with the dust of libraries. To read the life of the genuine lover of out-door nature such as Agassiz or Darwin, is like a breath from a glacier in the valley of the Rhone; to study the record of a life so simple, so earnest, so pure, so reverent, is a lesson for all time.

T. G. BONNEY.

OUR BOOK SHELF.

Beiträge zur Biologie und Anatomie der Lianen, im Besonderen der in Brasilien einheimischen Arten. Von Dr. H. Schenck. Zweiter Theil. Beiträge zur Anatomie der Lianen. 8vo. pp. 271, tt. 12. (Jena: Gustav Fischer, 1893.)

IN a brief notice of the first part of Dr. Schenck's "Beiträge" (NATURE, vol. xli., p. 514), the fact that it was only the first part was overlooked; hence the remark that all the plates of that part were devoted to the illustration of the external morphology of chiefly woody climbers loses the force it would have had, had it referred to the whole work. The second part has now appeared, and this treats of the anatomy, whilst the first treats of the biology of this class of plants. The two volumes form a valuable book of reference on this subject; and the illustrations include examples of the anatomy of the stems of climbing plants belonging to about twenty-five natural orders. There are twelve large folded plates containing 178 figures, all very laboriously and carefully drawn. The Sapindaceæ and Leguminosæ are most numerously represented, and present some highly curious structures.

W. B. H.

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.]*

The Late Solar Eclipse.

IN his account of the work of the Eclipse Expedition at Fundium Mr. Fowler seeks to explain his inability to obtain the photographs at the moment of totality by the assumption that he received the signal of the beginning of totality at least ten seconds too late, and he bases this assumption on his own estimate of the difference in time which elapsed between my signal and that of M. Coculesco, one of the French observers at Fundium.

I did not hear M. Coculesco's signal, as my head was necessarily enveloped in the dark cloth of my photometer at the moment, but M. Deslandres, the chief of the French party, with whom I returned to Europe, tells me that he estimated the interval at about two seconds, with which estimate M. Coculesco concurs.

There would seem to be good reason to believe that the actual time of the total phase was several seconds less than we had been led to expect. The chronometer observations at Fundium (lat. 14° 7′) gave 243 seconds. M. Bigourdan, who was specially charged by the Bureau des Longitudes to make accurate observations on this point at Joal, which is a few miles to the west of Fundium, and in lat. 14° 9′, informs me that the total phase there was 241 seconds.

It is possible, therefore, that Mr. Fowler's estimate of 10 seconds may not only have been erroneous in consequence of the known difficulty of accurately estimating a time interval during the exciting conditions of an eclipse, but may also have arisen from the fact that the actual eclipse was shorter than the calculated one.

T. E. THORPE.

Daylight Meteor, March 18.

THIS meteor, reported to NATURE by Dr. Rorie of Dundee, was also seen by Mr. A. G. Linney at Ackworth, near Pontefract. Careful comparison of their records gave a probable path from just S.E. of Lanark to 30 or 40 miles W. of Mull. Notes received later from the Fort William Low Level Observatory make it probable that the end was nearer there, say just N. of Mull. The former gives an actual path of 180 miles, from a height of 140 to 42 miles; the latter, 140 miles, ending at a height of 40 miles or less. If Dr. Rorie's time is correct, it travelled at a rate of 36 or 28 miles per second, both being rapid. This accounts for the magnificent streak. As this floated across to Dundee in three quarters of an hour, the central part must have in that time travelled 95 or 85 miles at a height of 100 to 90 miles above the earth, and in an E.N.E. direction. Thus its velocity seems to have exceeded 100 miles an hour. The Krakatão dust reached us in the same direction, its greatest height being 30 to 40 miles, and speed 72 miles per hour. A greater speed at greater altitude quite agrees with theoretical probabilities, although the increase seems very great.

J. EDMUND CLARK.

Roche's Limit.

A LETTER has been addressed by Mr. D. D. Heath to the Editor of NATURE on the statical problem involved in "G. R.'s" approximate method of finding Roche's limit. This letter has been submitted to me, and I have thus been led to look more closely into "G. R.'s" proof, which I adopted in a recent letter to NATURE (April 20, 1893, p. 581). Mr. Heath shows that both "G. R." and I have omitted the factor 2 from our result, and I now see besides that a statical solution is insufficient for the problem in question.

The problem may be stated thus:—To find at what distance two equal spheres in contact can revolve in a circular orbit round a third, the centres of the three spheres being in a straight line.

Take the following notation:—The single sphere of density σ and unit radius; the two spheres each of unit density and radii r; c, the distance from the centre of the single sphere to the point of contact of the two; and ω the angular velocity of the system.

The problem may be rendered statical by introducing the conception of centrifugal force estimated from the centre of inertia of the system, which is also the centre of rotation. The distance of the centre of inertia from the point of contact of the two spheres is $c\sigma/(\sigma+2r^3)$.

Then the three equations, only two of which are independent, which express the equilibrium of the spheres are:—

$$\omega^2\left(\frac{c\sigma}{\sigma+2r^3}+r\right)=\frac{\frac{4}{3}\pi\sigma}{(c+r)^2}+\frac{\frac{4}{3}\pi r^3}{(2r)^2},$$

$$\omega^2\left(\frac{c\sigma}{\sigma+2r^3}-r\right)=\frac{\frac{4}{3}\pi\sigma}{(c-r)^2}-\frac{\frac{4}{3}\pi r^3}{(2r)^2},$$

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

Adding the first two of these and dividing by $\frac{2}{3}\pi\sigma$, and then subtracting the second from the first and dividing by $\frac{2}{3}\pi r$, we have

$$\frac{3\omega^2}{\pi}\left(\frac{c}{\sigma+2r^3}\right)=\frac{4(c^2+r^2)}{(c^2-r^2)^2},$$

$$\frac{3\omega^2}{\pi}=1-\frac{8c\sigma}{(c^2-r^2)^2}.$$

Eliminating ω^2 we have

$$c(c^2-r^2)^2-8c^2\sigma=4(c^2+r^2)(\sigma+2r^3),$$

or

$$c^5-2c^4r^2-c^2(12\sigma+8r^3)+cr^4-4r^2(\sigma+2r^3)=0,$$

a quintic for determining c, the approximation to Roche's limit. If the two spheres are infinitely small compared with the single one, this reduces to

$$c^3=12\sigma.$$

Thus the factor 16 (which, as Mr. Heath shows, should have been 8) of "G. R.'s" and of my previous letter must be replaced by 12, when the rotation is taken into account. In the notation used before, we therefore have as the approximation to Roche's limit

$$2\cdot29\mathrm{R}\times\left(\frac{\mathrm{D}}{d}\right)^{\frac{1}{3}}.$$

Proceeding further, as I did before, to find when three homogeneous spheres are in contact, so that $\sigma=1$ and $c=2r+1$, we have—

$$22r^5-25r^4-60r^3+14r^2+38+11=0.$$

Unity is a solution of this, so that three equal spheres are in contact—an obviously correct solution.

There is another root with $r=2\cdot08$, so that the two spheres are each much larger than the third.

These solutions of course give no approximation to that of the problem to which the latter part of my letter referred.

May 3.

G. H. DARWIN.

The Use of Ants to Aphides and Coccidæ.

MR. COCKERELL is not quite accurate in saying that I have "adduced the production of honey-dew by aphides as a difficulty in the way of the Darwinian theory" (NATURE, vol. xlvii. p. 608). In the passage to which he alludes I have said, that the relationship which in this matter subsists between ants and aphides is one of the very few instances where it can be so much as suggested that the structures or instincts of one species have exclusive reference to the needs of any other species. Therefore, even if this suggestion were not thus opposed to all the analogies of organic nature, "most of us would probably deem it prudent to hold that the secretion must primarily be of some use to the aphis itself, although the matter has not been sufficiently investigated to inform us of what this use is" ("Darwin and after Darwin," p. 292).

But my object in now writing is to corroborate Mr. Cockerell's explanation. For, on looking up my references, I find a letter from the Rev. W. G. Proudfoot, dated March 26, 1891, in which he communicates the following observations:—

"On looking up I noticed that hundreds of large black ants were going up and down the tree, and then I saw the aphides. . . . But what struck me most was that the aphides showered down their excretions independently of the ants' solicitations, while at other times I noticed that an ant would approach an aphis without getting anything, and would then go to another. I was struck with this, because I remembered Mr. Darwin's inability to make the aphides yield their secretion after many experiments. A large number of hornets were flying about the tree, but seemed afraid of the ants; for when they attempted to alight, an ant would at once rush to the spot, and the hornet would get out of its way."

From this it seems probable that, but for the presence of the ants, the aphides would have been devoured by the hornets. It also appears that Darwin's explanation is likewise true, viz. that the aphides are bound to get rid of their excretions in any case, and therefore that "they do not excrete solely for the benefit of the ants."

GEORGE J. ROMANES.

Christ Church, Oxford, May 6.

MR. COCKERELL'S letter (NATURE, vol. xlvii. p. 608) suggests the possibility that the following fact bearing on the connection between a coccid and another member of the Aculeate Hymenoptera may be interesting. I have a quantity of *Cotoneaster microphylla* covering a long sunny bank, and this shrub is much infested by a coccid, *Secanium ribis*. The queen wasps (usually early in June, but this year they are beginning now) are attracted in great numbers by the secretion from the coccid and may be taken with a common ring net and destroyed, to the great advantage of my garden. As to the visits of the wasps being of any advantage to the coccid I am somewhat sceptical, though no doubt they are to the wasps—when they are not caught!

ALFRED O. WALKER.

Nant y Glyn, Colwyn Bay, May 5.

ON THE EARLY TEMPLE AND PYRAMID BUILDERS.

I HAVE in previous articles discussed the orientation of many temples in various parts of Egypt. It will have been seen that it has been possible to divide them into solar and stellar temples, and that in the case of the former both solstices and equinoxes have been in question.

I have also referred to the very considerable literature which already exists as to the pyramids, and shown how the most carefully constructed among them are invariably oriented truly to the four cardinal points, and further that it is possible that some parts of their structures might have served some astronomical purpose, since astronomical methods must certainly have been employed in their construction.

It has also been suggested that the fundamental difference between solstitial and equinoctial worships indicated by the solstitial temples and the pyramids required nothing less than a difference of race to explain it. I propose now to inquire if there be any considerations which can be utilised to continue the discussion of the question thus raised on purely astronomical grounds. It is obvious that if sufficient tradition exists to permit us to associate the various structures which have been studied astronomically with definite periods of Egyptian history, a study of the larger outlines of that history will enable us to determine whether or not the critical changes in dynasties and rulers were or were not associated with critical changes in astronomical ideas as revealed by changes in temple-worship. If there be no connection the changes may have been due to a change of idea only, and the suggestion of a distinction of race falls to the ground.

In a region of inquiry where the facts are so few and difficult to recognise among a mass of myths and traditions, to say nothing of contradictory assertions by different authors; the more closely we adhere to a rigidly scientific method of inquiry the better. I propose to show, therefore, that there is one working hypothesis which seems to include a great many of the facts, and I hope to give the hypothesis and the facts in such a way that if there be anything inaccurately or incompletely stated it will be easy at once to change the front of the inquiry and proceed along the new line indicated.

I may begin by remarking that it is fundamental for the hypothesis, that the temples of On or Heliopolis, as stated by Maspero and other high authorities, existed before the times of Mini (Menes) and the pyramid builders, whatever may have been the date of the original foundation of Thebes.

Before Mini, according to Maspero, "On et les villes du Nord avaient eu la part principale dans le développement de la civilisation Égyptienne. Les prières et la hymnes, qui formèrent plus tard le noyau des livres sacrés, avaient été ridigés à On."[1]

The working hypothesis is as follows:—

1. The first civilisation as yet glimpsed in Egypt, represented by On or Heliopolis, was a civilisation with a solstitial solar worship associated with the rise of the Nile. A northern star was also worshipped.

2. Memphis (possibly also Sais, Bubastis, Tanis, and other cities with east and west walls) and the pyramids were built by an invading race from a land where the worship was equinoctial. A star rising in the east was worshipped at the equinox.

3. The blank in Egyptian history between the sixth and eleventh dynasties was associated with conflicts between these races, which were ended by the victory of the representatives of the old worship of On. After them pyramid building ceased and solstitial worship was resuscitated; Memphis takes second place, and Thebes, a southern On, so far as solstitial solar worship is concerned, comes upon the scene as the seat of the twelfth dynasty.

[1] "Histoire ancienne," p. 41.

4. The subsequent historical events were largely due to conflicts with intruding races. The intruders established themselves in cities with east and west walls, and were on each occasion driven out by solstitial solar worshippers who founded dynasties (eighteenth and twenty-fifth) at Thebes.

1.—*On.*

I have taken another occasion of remarking how the various worships at Thebes were reflected in the orientation of the temenos walls. The so-called "symmetrophobia" of the Egyptians was full of meaning, which in this case, at all events, is no longer hidden. If we note this reflection, as we can over and over again, where both temples and walls still stand, it is fair to assume that where the walls alone remain the temples which they once enclosed, long since destroyed, had the same relation. These considerations, alas, have to be appealed to in the case of Heliopolis, to say so far nothing of Abydos and Memphis.

At Heliopolis the so-called "symmetrophobia" as indicated by the trend of the mounds given in Lepsius's plan, is so strong that in spite of the fact that only one obelisk of one temple remains, it is easy to show that both solstitial solar worship and star worship were carried on, if walls had the same relation to the included temples at On as they had at Thebes.

The solar temple at On has entirely disappeared. As may be gathered from the remains of the mounds, it lay in the line of the solstices. As the gods included Rā, Atmu, and Osiris, probably like the temple of Amen Rā at Thebes there were two temples back to back. At Thebes the temples were directed north-west—south-east, at On south-west—north-east.

My observations of the orientation of the obelisk show that the temple of which it formed part may have possibly been the first of the series which includes the temple of Mut at Thebes, and other temples, there and at Abydos; that is the worship of Set was in question, to speak generically. Now, according to Maspero,[1] Sit or Set formed one of the divine dynasties, being associated with the sun and air gods at On, *i.e.* with Rā, Atmu, Osiris, Horus, and Shou.

At Abydos, as also can be determined by the orientation of the walls, one of the oldest temples was probably a solstitial one. The stellar temples sacred to Set were built much later than the solar temple.

Like On, Abydos was a sacred city.[2]

"C'est comme ville sainte qu'elle était universellement connue. Ses sanctuaires etaient célèbres, son dieu Osiris vénéré, ses fêtes suivies par toute l'Égypte; les gens riches des autres nomes tenaient à honneur de se faire dresser une stèle dans son temple."[3]

If it be found that the references to "ancestors," and "divine ancestors," occur after the eleventh dynasty, the race represented by On may be referred to (see the articles on the Egyptian year), and it may be that so often referred to as the Hor schesu.

Only one star temple, as I have said, is still represented at On; those at Abydos are known to be late. The term, then, of Sun-worshippers was highly distinctive, and there is reason to believe that the stellar observations were connected with the solar worship.

2.—(*a*) *The East and West Walls and Pyramid Builders.*

On the hypothesis these came from a country where the worship was equinoctial.

We are justified from what is known regarding the rise of the Nile as dominating and defining the commencement of the Egyptian year that other ancient peoples placed under like conditions would act in the same way.

Now what the Nile was to Egypt the valleys of the

[1] *Op. cit.* p. 33.
[2] Maspero, *op. cit.*, p. 21.
[3] It is important to inquire if this took place after the advent of the eleventh dynasty.

Tigris and the Euphrates were to the early Chaldæan empire. Like the Nile, these valleys were subject to annual inundations, and their fertility depended, as in Egypt, upon the manner in which the irrigation was looked after.

But unlike the Nile, the commencement of the inundation of these rivers took place near the vernal equinox; hence the year, we may assume, began then, and, reasoning by analogy, the worship in all probability was equinoctial.

A people entering Egypt from this region, then, would satisfy one condition of the problem, but is there any evidence that this people built their solar temples and temple walls east and west, and that they also built pyramids?

There is ample evidence, although, alas! the structures in Chaldæa, being generally built in brick and not in stone, no longer remain, as do those erected in Egypt. Still, in spite of the absence of the possibility of a comparative study, research has shown that in the whole region to the north-east of Egypt the temenos walls of temples and the walls of towns run east and west; and though at present actual dates cannot be given, a high antiquity is suggested in the case of some of them. Further, the temples which remain in that region where stone was procurable, as at Palmyra, Baalbec, Jerusalem, all lie east and west. But more than this, it is well known that from the very earliest times pyramidal structures, called ziggurats, some 150 feet high, were erected in each important city. These were really observatories; they were pyramids built in steps, as clearly shown from pictures found on contemporary tablets; and one with seven steps and of great antiquity, it is known, was restored by Nebuchadnezzar about 600 B.C. at Babylon.

A second condition of the hypothesis is therefore satisfied.

But did this equinox-worshipping, pyramid-building race live at anything like the time required? Prof. Sayce showed in the Hibbert lectures which were delivered in the year 1887 that recent finds have established the existence of a King Sargon I. at Agade in Chaldæa 3800 B.C. Hence it seems that a third condition of the hypothesis is satisfied by this recent discovery. There was undoubtedly an equinox-worshipping, pyramid-building race existing in Chaldæa at the time the Egyptian pyramids are supposed to have been built.

Hommel, in a recent paper on the Babylonian origin of Egyptian culture, shows that the names of the gods corresponded in many cases with the names of deities mentioned in the oldest Egyptian pyramid texts. . . . The names were represented by exactly the same signs in both Babylonian and Egyptian hieroglyphics . . . the name and signs of Osiris the Babylonian Asari are represented in both countries by an eye. He contends that there had been a direct communication between the two civilizations, and that the Babylonian was the older of the two.

Next let us return to Egypt.

We find at Memphis, Sais, Bubastis, and Tanis east and west walls which at once stamp those cities as differing in origin from On, Abydos, and Thebes, where, as I have shown, the walls trend either north-west—south-east or north-east—south-west.

For Memphis, Sais, and Tanis, the evidence is afforded by the maps of Lepsius. For Bubastis it depends upon the statement of Naville, that the walls run "nearly from east to west," and with the looseness too often associated with such statements, it is not said whether true or magnetic bearings are indicated.

Associated with these east and west walls there is farther evidence of great antiquity. Bubastis, according to Naville,[1] has afforded traces of the date of Cheops and Chephren, and it is stated by Manetho to have existed as early as the second dynasty.

[1] "Bubastis," preface, p. iv.

It is also generally known that the pyramids in Egypt are oriented east and west. Nor is this all.

One of the oldest, if not the oldest, pyramid known, is a step pyramid modelled on the zuggurat pattern: the so-called "step pyramid of Sakkarah." The steps are six in number, and vary in height from thirty-eight to twenty-nine feet, their width being about six feet. The dimensions are (352 north and south) × (396 east and west) × 197 feet. Some authorities think this pyramid was erected in the first dynasty by the fourth king (Nenephes of Manetho, Āta of the tablet of Abydos.) The arrangement of chambers in this pyramid is quite special.

The claim to the highest antiquity of the step pyramid is disputed by some in favour of the "false pyramid" of Mêdûm. It also is really a step pyramid 115 feet high; its outline, which conceals some of the steps, shows three stages, seventy, twenty, and twenty-five feet high; but in its internal structure it is really a step pyramid of six stages.

This pyramid must, according to Petrie, be attributed to Seneferu; but De Rougé has given evidence to the contrary.[1] Seneferu was a king of the fourth dynasty.

We have at Dashour the only remaining abnormal pyramid called the blunted pyramid, for the reason that the inclination changes at about one-third of the height. This pyramid forms one of a group of four, two of stone, and, be it carefully borne in mind, two of brick; their dimensions are 700 × 700 × 326 feet; 620 × 620 × 321 feet; 350 × 350 × 90 feet; and 343 × 343 × 156 feet.

One of these pyramids was formerly supposed to have been built by Seneferu; if any of them had been erected by King Ousertsen III. of the twelfth dynasty, as was formerly thought, the hypothesis we are considering would have been invalid.

Only after Seneferu, then do we come to the normal Egyptian pyramid, the two largest at Gizeh built by Cheops and Chephren (fourth dynasty) being, so far as is accurately known, the oldest of the series. (According to Mariette the date of Mini is 5004 B.C., and the fourth dynasty commenced in 4235.)

Associated with the cities with east and west walls are temples facing due east, fit, therefore, to receive the rays of the morning sun rising at an equinox.

Associated with these pyramids carefully oriented east and west, we find on their eastern sides some distance away, and on a line passing through their centres at right angles to a meridian line, temples facing due west, the clearest possible indication of equinoctial worship. At sunset at the equinox the sepulchral chamber and the sun were in line from the adytum. The priest faced a double Osiris.

In the case of the pyramid of Chephren, not only have we, as I hold, such a temple of Osiris, but the Sphinx granite temple was most probably the crypt of a temple of Isis, its relation to the south face of the pyramid being borne in mind. If this were so Osiris was a name both for the solstitial and equinoctial sun.

Other pyramids were built at Sakkarah during the sixth dynasty, but it is remarkable that such a king as Pepi-Meri-Rā should not have imitated the majestic structures of the fourth dynasty. He is said to have built a pyramid at Sakkareh, but its obscurity is evidence that the pyramid idea was giving way, and it looks as if this dynasty were really on the side of On,[2] for the authority of Memphis declined, and Abydos was preferred, while abroad Sinai was reconquered, and Ethiopia was kept in order.[3]

The sphinx (oriented true east) must also be ascribed to the earliest pyramid builders; it could not have been built before their intrusion. The Colossi of the plain at

[1] Maspero, *op. cit.* p. 59. [2] Maspero, *op. cit.* p. 80.
[3] Further, it is known that there was some connection between Pepi-Meri-Rā and the eleventh dynasty of Thebes. Maspero, *op. cit.* p. 91.

Thebes was a subsequent reply of the On solstitial worship to it.

(*b*) *The Worship of the Bull by the Pyramid Builders.*

There is a subsidiary point in connection with the pyramid builders and equinoctial worship.

The worship of Apis preceded the building of pyramids. Mini is credited by Elian with its introduction,[1] but at any rate Kakau of the second dynasty issued proclamations regarding it,[2] and a statue of Hapi was in the temple of Cheops.[3]

It is stated that the first month of the Chaldæan year was dedicated to the "propitious bull," and that the figure of a bull constantly occurs on the monuments as opening the year. Now the sun *at the vernal equinox* 4500 B.C. was in the constellation Taurus. Biot has shown that the equinox occurred with the sun near the pleiades in 3285 B.C. We seem driven to the conclusion that the constellation of the bull dates from this time, and that Hapi represented it.[4]

(*c*) *The Art of the Pyramid Builders.*

Another connecting link is found in the diorite statues found in the temple of Chephren, at the pyramids, and at Tell-loh (ancient Sirgalla) by M. de Sarzec in 1881.

This last find consisted of some large statues of diorite, and the attitude chosen was that of Chephren himself as represented in the Museum of Gizeh.

This indicates equality in the arts and the possession of similar tools in Chaldæa and Egypt about the time in question.

(*d*) *The Star Worship of the Pyramid Builders.*

I have given before the gods of Heliopolis, and have shown that with the exception of Sit none are stellar; and that the temple of Sit is still represented. But we find in pyramid times the list is vastly changed; only the Sun gods Ra, Horus, Osiris, are common to the two. As new divinities we find[5]:—

Isis.
Hathor.
Nephthys.
Ptah.
Selkit.
Sokhit.

Of these the first two and the last two undoubtedly symbolised stars, and there can be no question that the temple of Isis at the pyramids was built to watch the rising of some of them.[6] Of Iris and Hathor I have already written at length, and I think the stars are now known. The others are more doubtful, but it may be that Ptah = Capella and Selkit = Antares.

But it is also stated that at Memphis[7] [time not given] there were temples dedicated to Soutekh and Baal. Now this is of great importance, for I suppose there is now no question among Egyptologists that the gods Set, Sit, Typhon, Bes, Soutekh, Soutkhou are identical. It is also equally well known that Soutekh was a god of the Canaanites[8] that the hippopotamus, the emblem of Set and Typhon, was the hieroglyph of the Babylonian god Baal,[9] and Bes is identified with Set in the book of the dead.[10]

[1] Maspero, *op. cit.* p. 44, note. [2] Maspero, *op. cit.* p. 46.
[3] Maspero, *op. cit.* p. 64.
[4] Not only the bull; there is evidence in favour of the view that the goddess Selk = Antares. If so, the scorpion constellation had also been established, and *both* equinoxes marked by constellations in the time of Cheops. [5] Maspero, *op. cit.* p. 64.
[6] The temple of Saïs, as I have said, had east and west walls, and so had Memphis, according to Lepsius. The form of Isis at Saïs was the goddess Neith, which, according to some authorities, was the precursor of Athene. The temple of Athene at Athens was oriented to the Pleiades.
[7] Maspero, *op. cit.* p. 357.
[8] Maspero, *op. cit.* p. 165. [9] Pierret, p. 4. [10] *Idem*, p. 48.

Jensen in his "Kosmologie der Babylonier," p. 16, points out that Bīl was the name for the pole of the equator. If this be the Baal referred to by Pierret, we get the most marvellous coincidence between the Egyptian and Babylonian star-worship and suggestion of a common origin among an astronomically-minded people.

This suggests that the founders of On and Memphis had a common origin, and the Memphitic intrusion took place after solar solstitial worship had been introduced at On. This worship could not have been brought into Egypt from any other country, bordering on Chaldæa, and its ultimate predominance is the origin of the myth of Horus slaying the hippopotamus. Nay, it may be also suggested that the predominance was brought about by men and ideas reaching On from the south, so that the myth had a single celestial and a double terrestrial side.

The Hawk God of Edfû, Harhouditi, had for servants a number of individuals called Masniou or Masnitiou = blacksmiths, just as the Hawk God of the Delta, Harsiisit, has for his entourage the Shosou Horou. Maspero in a most interesting paper[1] has recently called attention to some customs still extant among the castes of blacksmiths in Central Africa, which have suggested to him that the followers of the Edfû Horus may have come from that province.

He writes: "C'est du sud de l'Égypte que les forgerons sont remontés vers le nord, leur siège primitif était le sud de l'Égypte, la partie du pays qui a le plus des rapports, avec les régions centrales de l'Afrique et leurs habitants."

Then after stating the present conditions of these workers in equatorial Africa, where they enjoy a high distinction, he concludes:—

"Je pense qu'on peut se représenter l'Horus d'Edfou comme étant au début, dans l'une de ses formes, le chef et le dieu d'une tribu d'ouvriers travaillant le métal, ou plutôt travaillant le fer. On ne saurait en effet se dissimuler qu'il y a une affinité réelle entre le fer et la personne d'Horus en certains mythes. Horus est la face céleste (horou), le ciel, le firmament, et ce firmament est de toute antiquité, un toit de fer, si bien que le fer en prit le nom de ba-ni-pit, métal du ciel, métal dont est formé le ciel: Horus l'aîné, Horus d'Edfou, est donc en réalité un dieu de fer. Il est, de plus, muni de la pique ou de la javeline à point de fer, et les dieux qui lui sont apparentés, Anhouri, Shou, sont de piquiers comme lui, au contraire des dieux du nord de l'Égypte, Ra, Phtah, etc., qui n'ont pas d'armes à l'ordinaire. La légende d'Harhouditi conquérant l'Égypte avec les masniou serait-elle donc l'écho ointain d'un fait qui se serait passé au temps antérieurs à l'histoire? Quelque chose comme l'arrivée des Espagnols au milieu des populations du Nouveau Monde, l'irruption en Égypte de tribus connaissant et employant le fer, ayant parmi elles une caste de forgerons et apportant le culte d'un dieu belliqueux qui aurait été un Horus ou se serait confondu avec l'Horus des premiers Egyptiens pour former Harhouditi. Ces tribus auraient été nécessairement d'origine Africaine et auraient apporté de nouveaux éléments Africains à ceux que renfermait déjà la civilisation du bas- Nil. Les forgerons auraient perdu peu à peu leurs privilèges pour se fondre au reste de la population: à Edfou seulement et dans les villes où l'on pratiquait le culte de l'Horus d'Edfou, ils auraient conservé un caractère sacré et se seraient transformés en un sorte de domesticité religieuse, les masniou du mythe d'Horus, compagnons et serviteurs du dieu guerrier."

3.—*The Work of the Eleventh and Twelfth Dynasties.*

We have next to consider what happened after the great gap in Egyptian history between the sixth and twelfth dynasties, 3500 B.C.–2851 B.C. (Mariette), from

[1] *L'Anthropologie*, July-August, 1891, No. 4.

Nitocris to Amenemhat I. We pass to the Middle Empire.

Amenemhat I. built no pyramids, he added no embellishments to Memphis; but he took Heliopolis under his care, and now we first hear of Thebes.[1]

Usertsen I. built no pyramids, he added no embellishments to Memphis, but he also took Heliopolis under his care, and added obelisks to the temples, one of which remains to this day. Further, he restored the temple of Osiris at Abydos, and added to the temple of Amen-Rā at Thebes.[2]

Surely it is very noteworthy that the first thing the kings of the twelfth dynasty did was to look after the only three temples in Egypt of which traces exist, which I have shown to have been oriented to the solstice.

It is right, however, to remark that there seems to have been a mild recrudescence of pyramid building towards the end of the twelfth dynasty, and immediately preceding the Hyksos period, whether as a precursor of that period or not.

Usertsen's views about his last home have come down to us in a writing by his scribe Mirri:[3]—

"Mon maître m'envoya en mission pour lui préparer une grande demeure éternelle. Les couloirs et la chambre intérieure étaient en maçonnerie et renouvelaient les merveilles de construction des dieux. Il y eut en elle des colonnes, sculptées, belles comme le ciel, un bassin creusé qui communiquait avec le Nil, des portes, des obélisques, une façade en pierre de Rouou."

There was nothing pyramidal about this idea, but 150 years later we find Amenemhat III. returning both to the gigantic irrigation works and the pyramid building of the earlier dynasties.

The scene of these labours was the Fayyûm, where, to crown the new work, two ornamental pyramids were built, surmounted by statues, and finally the king himself was buried in a pyramid near the Labyrinth.

4.—*The Work of the Eighteenth Dynasty.*

The blank in Egyptian history between the twelfth and eighteenth dynasties is known to have been associated with the intrusion of the so-called Hyksos. It is supposed these made their way into Egypt from the countries in and to the west of Mesopotamia. It is known that they settled in the cities with east and west walls. They were finally driven out by Aahmes, the king of solstitial solar Thebes, who began the eighteenth dynasty.

In (*a*) I have shown what happened after the first great break in Egyptian history—a resuscitation of the solstitial worship at On, Abydos and Thebes.

I have next to show that precisely the same thing happened after the Hyksos period (Dyn. 13 (?) Mariette, 2233 Brugsch; Dyn. 18, 1703 B.C., Mariette) had disturbed history for some 500 years.

It is known from the papyrus Sellier (G.C. 257) that Aāhmes, the first king of the eighteenth dynasty, who re-established the independence of Egypt, was in reality fighting the priests of Soutekh in favour of the priests of Amen Rā, the solstitial solar god, a modern representative of Atmu of On.

Amen-Rā was the successor of Menthu, the successor of Atmu of On. So close was the new worship to the oldest at On, that at the highest point of Theban power the third priest of Amen took the same titles as the Grand Priest of On, "who was the head of the first priesthood in Egypt."[4] The "Grand Priest of On," who was also called the "Great Observer of Rā and Atmu," had the privilege of entering at all times into the *Habenben* or Naos. The priest Padouamen, whose mummy was found in 1891, bore these among his other titles.

[1] Maspero, *op. cit.*, p. 112.
[2] Maspero, *op. cit.* p. 112.
[3] Maspero, *op. cit.* p. 113.
[4] Virey, New Gizeh Catalogue, p. 263.

The assumption of the title was not only to associate the Theban priesthood with their northern *confrères*, but surely to proclaim that the old On worship was completely restored.

5.—*The Work of the Twenty-fifth Dynasty.*

There was another invasion from Syria, which founded the twenty-second dynasty, and again the government is carried on in cities with east and west walls (Sais, Tanis, and Bubastis). The solstitial solar priests of Thebes withdraw to Ethiopia. They return, however in 700 B.C., drive out the Syrian invaders, and, under Shabaka and Taharga, found a dynasty (the twenty-fifth) at Thebes, and embellish the solstitial solar temples there.

6.—*Anthropological Evidence.*

It will be seen then that a general survey of Egyptian history does suggest conflict between two races, and this of course goes to strengthen the view that the temple building phenomena suggest two different worships, depending upon race distinctions.

We have next to ask if there is any anthropological evidence at our disposal. It so happens that Virchow has directed his attention to this very point.[1]

Premising that a strong race distinction is recognised between peoples having brachycephalic or short, and dolicocephalic or long, skulls, and that the African races belong to the latter group, I may give the following extract from his paper:—

"The craniological type in the Ancient Empire was different from that in the middle and new. The skulls from the Ancient Empire are brachycephalic, those from the new and of the present day are either dolichocephalic or mesaticephalic; the difference is therefore at least as great as that between the dolichocephalic skulls of the Frankish graves and the predominantly brachycephalic skulls of the present population of South Germany. I do not deny that we have hitherto had at our disposal only a very limited number of skulls from the Ancient Empire, which have been certainly determined; that therefore the question whether the brachycephalic skull-type deduced from these was the general or at least the predominant one cannot yet be answered with certainty, but I may appeal to the fact that the sculptors of the Ancient Empire made the brachycephalic type the basis of their works of art too."

It will be seen, then, that the anthropological as well as the historical evidence runs on all fours with the results to be obtained from such a study of the old astronomy as the temples afford us.

J. NORMAN LOCKYER.

NOTES.

ON Monday, May 29, the Duke of Connaught will open the new engineering and electrical laboratories at University College, London.

A GENERAL meeting of the members of the Federated Institution of Mining Engineers will be held in the rooms of the Institution of Civil Engineers, 25, Great George Street, Westminster, on Thursday, June 1, at 12 noon, and on Friday, June 2, at 10 a.m.

THE Niederrheinische Gesellschaft für Natur- und Heilkunden at Bonn, proposes to celebrate its seventy-fifth anniversary on July 2. A scientific meeting will be held in the forenoon in the music hall of the University of Bonn, and at one o'clock the members will dine together at the hotel "Zum Goldenen Stern." In the afternoon there will be an excursion to Rüngsdorf.

[1] Prof. R. Virchow: "Land und Leute im alten und neuen Aegypten." *Verhandlungen der Gesellschaft für Erdkunde zu Berlin*, pp. 434-436, Band xv. No. 9.

CAPTAIN E. C. HORE, who was for many years in command of the mission steamer on Lake Tanganyika, and received in 1890 one of the Royal Geographical Society's awards for his observations on the physical geography of the lake, has arranged an interesting little exhibition at 48, Pall Mall, which will be formally opened tomorrow, May 19, at 4 p.m., when a number of distinguished African explorers and administrators will be present. The exhibition contains a number of African curios collected by Captain Hore, and models illustrating native life and industries in a very realistic manner. It will only be open for a few weeks, and is well worthy of a visit from all interested in the geography or in the future development of the region marked out by Nature as the future highway through the continent of Africa.

THE annual dinner of the Royal Geographical Society was held at the Whitehall Rooms, Hôtel Métropole, on Saturday, Sir M. E. Grant Duff in the chair. Among the toasts of the evening was that of "The Medallists Designate." In proposing this, the Chairman explained that the dinner usually took place on the evening of the anniversary meeting, but the rooms could not be obtained for that day, and therefore the medals had not yet been conferred. All would agree that the choice of the council had fallen upon very worthy recipients. The first was Mr. Selous, whom they welcomed that evening. The second medallist designate was Mr. Woodville Rockhill, an American diplomatist, who had made himself famous by his explorations in Western China and North-eastern Tibet. Mr. Selous, in responding, said that at a very early period of his African travels he had made sketch maps, and he had never ceased to do so in all the countries through which he had travelled. He had been able to make a pretty correct survey of Mashonaland, and he looked with the most intense pride and satisfaction to the fact that he had seen a British colony spring up in that country, which he was one of the first to explore. Lord Kelvin responded for "The Allied Sciences," proposed by Mr. Seebohm. Mr. W. T. Thiselton Dyer proposed "The Royal Geographical Society." The Chairman, in replying, said he looked back with pleasure upon the almost unclouded prosperity which the Society had enjoyed for the four years during which he had been President. Their numbers this year had sprung forward again, and their total number was close upon 3700.

THE *Botanisches Centralblatt* has published a full description of the newly established Biological Institute at Heligoland, which is now at full work. The Director is Prof. Heincke, with Dr. Hartlaub as assistant for zoology, and Dr. Ehrenbaum for the high-sea fisheries, while Dr. P. Kuckuck superintends the botanical investigations. Donations to the library are especially asked for.

M. DUCHARTRE has been elected President of the Botanical Society of France for the current year, with MM. Guignard, Clos, Poisson, and Zeiller as Vice-presidents.

THE greater part of the Kew Bulletin for February and March, which has just been issued, consists of an account of the known habits and the economic treatment of the insect commonly known as the palm weevil, which during the last five or six years has been doing enormous injury to the industry of cocoa-nut palm growing in British Honduras. The paper cannot fail to be of service to planters engaged in this industry. The number contains also, besides miscellaneous notes, the fifth decade of new orchids.

THE London Botanical Field Class, which was established in 1891, will make seven field excursions during the present summer, the first of them taking place on May 27. The director is Prof. G. S. Boulger.

DURING the past week the day temperatures have generally been considerably above the average for the season, the readings at some of the central and southern stations exceeded 70°, and reached from 75° to 80° over our south-eastern and south-midland counties; but in some parts of the north and north-west the daily maxima have not reached 60°. During the first part of the period barometric depressions approached the north of Scotland and spread southwards, bringing light rains to the northern and western parts of the country; but the fall was below the average amount, while in the south and east of England no rain fell until the 15th inst. The long drought, which in many places was brought to a close on Monday by the advance of a subsidiary depression over the southern portion of the kingdom, had lasted in parts of Kent and Hampshire for fifty-eight days, during which time absolutely no rain fell there. Towards the close of the period the type of weather became very unsettled, and thunderstorms occurred in many parts, accompanied by rain or hail, but, with few exceptions, the fall up to Tuesday, the 16th inst., was not heavy. The *Weekly Weather Report* of the 13th inst. showed that the amount of bright sunshine was much above the average. In London it was 76 per cent. of the possible amount, which is higher than any percentage previously recorded in the metropolis since sunshine instruments were established in 1880. In the Channel Islands the percentage was as high as 88, and over England generally it ranged from 60 to 78 per cent.

THE report of the Kew Committee for the year 1892, the publication of which was noted in our last issue, states that the principal magnetic disturbances were recorded on February 13 and 14, March 6 and 12, April 26, May 18, July 16 and 17, and August 12. The most marked disturbance was that which commenced on February 13; the oscillations were of a more extended and violent character than any which have been recorded during the last ten years. The tabulations of the meteorological traces and other observations have been transmitted to the Meteorological Office, and detailed information of all thunderstorms has been forwarded to the Royal Meteorological Society. Sketches of sun-spots were made on 178 days; on no occasion during the year, when observations have been taken, has the sun's surface been found free from spots, and the number of new groups enumerated has largely increased. The number of instruments verified during the year was nearly 21,000, the great majority being clinical thermometers, and, in addition, a large number of watches have been examined.

THE Meteorological Council have just issued a summary of rainfall and mean temperature for the first quarter of the twenty-eight years 1866 to 1893, based upon the observations published in the *Weekly Weather Report*. The figures show some interesting details of the weather in each of the twelve districts into which the country is divided for the purpose of weather forecasts. In every district except the north of Scotland and the east of England there was a deficiency in the amount of rainfall. In the principal wheat-producing districts the greatest deficiency was in the Midland Counties, being 1·1 inch, and the east of Scotland 1·3 inch, while in the principal grazing, &c., districts the deficiency was still larger, being 2·0 inches in the south-west of England, and 2·7 inches in the north-west of England. The deficiency for the whole of the British Islands (omitting the Channel Islands and the North of Scotland) was 1·3 inch. The temperature in every district exceeded the mean, except the north of Scotland, where it just equalled it. The largest excess was 1°·3 in the north of Ireland, and 1°·2 in the north-east of England. The excess for the British Islands generally was 0°·8; the mean temperature for the last quarter, notwithstanding the severe cold experienced at the beginning of the year having been only just exceeded once in the last nine years.

THE first part of Prof. Newton's "Dictionary of Birds" which has long been announced as in preparation will be published next month. It is based upon the articles contributed by him to the ninth edition of the "Encyclopædia Britannica," but contains large numbers of others by himself and Dr. Gadow, the Strickland Curator at Cambridge, together with contributions by Mr. Lydekker, Prof. Roy, and Dr. Shufeldt. The work is to consist of four parts, and when complete will form a demy 8vo volume of about 1000 pages, copiously illustrated, and the publishers Messrs. Adam and Charles Black, promise the second part in October next.

IN the current number of the American *Journal of Science* Mr. Pupin gives the second part of his paper on electrical oscillations of low frequency and their resonance (see NATURE, April 20, 1893). This portion consists chiefly of a theoretical investigation of the rise of potential in a circuit which is in resonance with a periodical impressed electromotive force. This rise was shown in a very striking manner by connecting two large choking coils and a condenser in series with the secondary of a transformer, a Thomson electrostatic voltmetre being connected to the terminals of the condenser, and the core of one of the choking coils consisting of a movable bundle of solf iron wires. The frequency of the impressed electromotive force being about 100 per second, the capacity of the condenser was adjusted until the removal of the plug was accompanied by bright sparks, showing that resonance was near. Then the movable iron core was adjusted till the voltmetre gave the longest deflection obtainable. In this way a rise from 60 volts (generated in the secondary and indicated by a Cardew voltmetre) to about 900 volts was easily obtained. The rise of potential is practically confined to the condenser, there being, however, a large and rapid increase in the current on the approach of resonance, which increase can be studied in a rough way by the pull which the choking coil exerts on the movable iron core when this is being adjusted to give resonance.

THE question as to the cause of earth currents is one of considerable interest, and has not yet been satisfactorily answered. A paper read before the Institute of Electrical Engineers by Mr. O. E. Walker, giving a further account of his observations made in India seems to show, however, a clear connection between the variations in the earth currents and those of the atmospheric pressure. On account of the long periods of settled weather experienced in India, that country is particularly well suited for the investigation of any such relation. Observations were made on four lines, and show, in almost every case, that in the morning the current flows from the inland place of observation to the coast, while in the afternoon the direction is reversed. The maximum current in one direction occurs at 10 a.m. local time, this also being the time of the morning maximum reading of the barometer, while the maximum current in the opposite direction occurs at 3 p.m., the time of the afternoon minimum of the barometer. Another point of interest is that the maxima of the earth currents occur when the diurnal variation of the declination is zero.

ON a clear, cold, winter afternoon, about half an hour before sunset, a peculiar phenomenon of refraction of light can be witnessed on a fresh field of snow, which is described by Mr. Albert W. Whitney in the *American Journal of Science*. Two roughly V-shaped paths, of especial, though not exclusive brilliancy, open away from the observer and towards the sun. The apex of one is perhaps six feet away, its angle 90°; the apex of the other is perhaps fifteen feet away, its angle 60°. The light is not diffused, but made up of many separate brilliant points, glowing with prismatic colours. The paths are broad, several degrees in width, their inner margin being more sharply defined than their outer limit. Measurements with a sextant have shown that all the glowing points lie in the surfaces of two cones, whose axes pass through the sun and the eye of the observer, and whose angles are approximately 22° and 46°. Hence the paths are hyperbolas, and their visibility depends upon the altitude of the sun above the horizon. Mr. Whitney explains the phenomenon as analogous to that of halos. It is largely, perhaps mostly, due to frost crystals. They form more slowly, hence more regularly, than snow crystals. The fact that snow hyperbolas are usually more conspicuous in the late afternoon than in the early morning, may be explained by the frost crystals needing a certain amount of clearing up by sun and wind of minute secondary accumulations of frost upon themselves, to make them fit for transmitting light. Another interesting fact concerns the relation of the other limb of the hyperbola to that upon the snow. If the observer walks so as always to keep one certain point in the path of light, his track will be an hyperbola; if now, from the apex of the hyperbola which he has traced, he advances a distance equal to his height multiplied by the cotangent of the altitude of the sun plus half the vertical angle of the cone, the figure which he now sees and the figure which he has traced upon the snow are the two limbs of the same hyperbola.

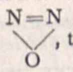
THE determination of the refractive index of the atmosphere has until recently been confined to the visible spectrum. Messrs. Kayser and Runge, in a communication to the Berlin Academy, describe a method of obtaining it for every portion of the photographic spectrum. If a prism is introduced between a Rowland concave grating and the sensitive plate, the rays are deflected, and the spectrum appears displaced on the plate. From the amount of this displacement and the distance of the prism from the plate it is easy to deduce the angle of deflection of the rays in question, and the refractive index of the prism. The prism used was hollow, made of copper and closed by quartz plates. The prism was filled with air under a pressure of about ten atmospheres Since the investigations of Mascart, Benoit, and Chappuis and Rivière have shown that the index of deviation of gases varies as the density, the refractive indices for air at zero and atmospheric pressure could be calculated from the results. Measurements were taken at seven different places along the spectrum, between wave lengths 563 and 236$\mu\mu$. The refractive indices for some of the Fraunhofer lines thus obtained are the following:—

A	1·0002902
D	1·0002919
F	1·0002940
G	1·0002959
H	1·0002975
N	1·0003000
$\lambda = 236\mu\mu$	1·0003217

These values are for air under normal temperature and pressure but not for dry air. To correct for moisture the last decimal place must be increased by 3, thus giving for D, for instance, the value 1·0002922. In the hands of previous workers, the last two figures have varied between 11 (Lorenz) and 47 (Ketteler).

NO fewer than six volumes containing French translations of writings by Mr. T. H. Huxley are now included in the "Bibliothèque Scientifique Contemporaine," issued by J. B. Baillière et Fils. The latest of these six volumes is a series of essays, entitled "Science et Religion."

A volume embodying the meteorological results deduced from observations taken at the Liverpool Observatory during the years 1889-90-91 has been published by order of the Mersey Docks and Harbour Board.

THE atomic refraction of nitrogen, in the free state as gas and in the various types of nitrogen compounds, forms the subject of a communication to the *Berichte* by Prof. Brühl, of Heidelberg. The refractive power of free gaseous nitrogen has been determined with the highest attainable accuracy by Biot and Arago, Dulong, and other later observers, and the value of the atomic refraction, calculated from the mean of all these determinations, is 2·21. As the simplest type of nitrogen compound ammonia gas is next considered, in which the three affinities of the nitrogen are attached by single linkage to the three hydrogen atoms. The molecular refraction of ammonia calculated from its refractive index is 5·65. Now, if it is admitted that the hydrogen in this simple compound possesses the same atomic refraction (1·05 for sodium light) as in the free state and in other ordinary combinations, an admission in support of which Prof. Brühl has previously adduced a considerable amount of experimental evidence, then the atomic refraction of the nitrogen in ammonia is 2·50. The compounds of nitrogen with oxygen are next discussed. The atomic refraction of oxygen for sodium light is 2·05, the molecular refraction of the free gas O_2 being 4·09. If one calculates the molecular refraction of nitric oxide, NO, by adding together the atomic refractions of the gaseous elements 2·21 and 2·05, the number 4·26 is obtained. It is interesting to find that the molecular refraction of nitric oxide, calculated from the values obtained experimentally by Dulong and by Mascart for the refractive index of the gas, is very nearly the same, 4·47. Hence in nitric oxide both elements retain about the same refractive power as in the free state. The case of nitrous oxide, N_2O, however, is quite different and leads to an interesting conclusion. Its molecular refraction calculated from the observed refractive index of the gas is 7·58. The value, however, obtained by summation of the values of its components, 2 × 2·21 and 2·05, is only 6·47. The very considerable increase of 1·11 is due to the fact that we are here dealing with a case of double linkage, , the two nitrogen atoms being mutually attached by two of their affinities. Indeed the increase is probably more than this, for the atomic refraction of oxygen in organic compounds of this type has been found by Prof. Brühl to be less than the value above ascribed to it. The atomic refraction of the nitrogen in N_2O is therefore at least 2·77. It is thus found that nitrogen as singly linked in ammonia possesses an atomic refraction of 2·50, when doubly linked, as in nitrous oxide, 2·77, and when trebly linked, as it probably is in the free gas, 2·21. The value therefore increases with double linkage, but curiously enough diminishes again with treble linkage, unlike that of carbon, which still further increases with treble linkage, and showing that there is some very essential difference between the nature of the two elements. Prof. Brühl concludes his interesting paper by discussing the various values of nitrogen when combined with carbon. When it is attached with only one of its valencies to a carbon atom, as in the tertiary amines, its atomic refraction is found to be 2·90, a very high value, higher than that of the diazo nitrogen in nitrous oxide. When doubly linked to carbon, C : N, as in the oxims, there is a much larger increase still, the exact amount of which Prof. Brühl prefers to state after carrying out further determinations on a larger number of compounds. In case of cyanogen gas, N ⋮ C · C ⋮ N, where triple linkage of nitrogen occurs, there is also a very considerable increment (1·52) in refraction. In the case of hydrocyanic acid, however, the molecular refraction corresponds almost exactly with that calculated from the empirical formula HCN, showing that the cyanogen in this compound and in cyanogen gas are quite different in molecular structure, a point which Prof. Brühl hopes further to elucidate by observations of the refraction of the nitriles and other allied organic nitrogen compounds.

Erratum.—In our chemical note of last week (p. 39) $SObl_2$ and Hbl should read $SOCl_2$ and HCl.

NOTES from the Marine Biological Station, Plymouth.—Last week's captures include the Anthozoa *Gorgonia verrucosa* and *Caryophyllia Smithii*, the Nemertine *Drepanophorus rubrostriatus*, the Mollusca *Sepia rupellaria* (= *biserialis*), *Galvina tricolor* and *Antiopa cristata*, and the Ascidians *Corella larvæformis* and *Fragarium elegans*. Several swarms of the medusa *Obelia lucifera*, full-grown and mature, were taken in the townets during the latter half of the week. Polychæte larvæ, so abundant earlier in the year, are now very scarce. Zoææ of *Porcellana*, on the other hand, have increased in numbers, and every townetting contains a variety of Decapod larvæ in different stages of development. The Hydroids *Eudendrium capillare* and *Antennularia antennina*, and the Polychæte *Sabellaria spinulosa* are now breeding.

THE additions to the Zoological Society's Gardens during the past week include two Red-winged Parrakeets (*Aprosmictus erythropterus*, ♀ ♀) from Australia, presented by Mr. H. Goodchild; two Ravens (*Corvus corax*) British, presented by Mr. Philip A. Wilkins; a Ducorp's Cockatoo (*Cacatua ducorpsi*) from the Solomon Islands, presented by Mr. R. Armitage; a Changeable Lizard (*Calotes versicolor*) from Ceylon, presented by Mr. H. L. Gibbs; a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, a Common Peafowl (*Pavo cristatus*, ♂) from India, deposited; a Yellow-cheeked Lemur (*Lemur xanthomystox*) from Madagascar, eleven Green Lizards (*Lacerta viridis*) South European, purchased; a Senegal Touracon (*Corythaix persa*) from West Africa, received in exchange; a Japanese Deer (*Cervus sika*) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE GREATEST BRILLIANCY OF VENUS.—Dr. G. Müller, whose work on the brightness of the major and some of the minor planets we referred to in this column two weeks ago (p. 15) contributes to *Astronomischen Nachrichten*, No. 3162, some interesting results with reference to the greatest brilliancy of Venus. That this planet does not appear brightest at the time of conjunction, but some days before or after, has been shown by the work of Halley, Lambert, &c., and the values, as obtained from their formulæ, are :—

Formula used.	The greatest brilliancy occurs at Angle of phase.	Elongation.	No. of days before or after inf. conj.	Greatest brilliancy.
	° ′	° ′		
Halley ...	117 56 ...	39 43 ...	36 ...	4·263
Lambert ..	103 46 ...	44 38 ...	51 ...	2·126
Bremiker ...	115 15 ...	40 52 ...	39 ...	2·772
Seeliger ...	116 0 ...	40 33 ...	38 ...	3·018

Referring to the curves of the observed and computed brightnesses, as here set forward by Dr. Müller, several important points may be noticed. In the former the maximum brightness takes place at a phase angle of 119°, decreasing very gradually to 140°, and after that more rapidly. At the maximum the curve is moderately flat, only a very small variation being noticed between position angle 100° and 140°, a period of 36 days.

Dr. Müller remarks that the statements of epochs given in the astronomical ephemerides have no practical interest. As an example showing the deviations of the values therein stated from those computed by his formula he works out the next epoch of the greatest brilliancy of Venus, which will be in inferior conjunction on February 15, 1894. The values for the brightness and the corresponding times result as follows :—

Jan. 9 ...	0h. G.M.T. ...	$h = -4·3776$
10 ..	,, ,, ...	−4·3798
11 ...	,, ,, ...	−4·3809
12 ...	,, ,, ...	−4·3809
13 ...	,, ,, ...	−4·3802
14 ...	,, ,, ...	−4·3782

which give for the epoch of greatest brilliancy January 11, 15h. M.T.G. The times of epoch, as given by the ephemerides, are :—

Berliner Ast. Jahrbuch	Jan. 8 ...	16h. M.T.G.
Nautical Almanac	11 ...	2h. ,,
Connaissance des Temps	12 ...	1h. ,,

FINLAY'S PERIODIC COMET.—This comet, which was discovered by Finlay in 1886, is one, if not the only one, of the periodic comets due this year. The following is a search ephemeris for the present month for intervals of four days:—

1893.	R.A. h. m. s.	Decl. ° ′
May 20	23 48 12	−4 24
24	0 5 24	−2 34
28	0 22 57	−0 40
June 1	0 40 53	+1 16

L'Astronomie FOR MAY.—This number commences with the discourses delivered by M. Tisserand and M. Flammarion before the Astronomical Society of France, the former "On the Progress of Astronomy during the Past Year," and the latter "On the Progress of the Society itself.—A brief but interesting article from the pen of Dr. Lorin, on "Celestial Photography," will be of special value to possessors of small instruments, since he shows how they can be adapted for the taking of such photographs. With reference to the late solar eclipse, several observatories have communicated their observations as made on the Continent, accompanying them with drawings, which are here inserted.

THE LUNAR ATMOSPHERE.—At the Observatory of Alger, M. Spée (*Comptes Rendus*, April 24, No. 17) made some interesting observations to find out whether any modifications due to a lunar atmosphere were produced in the lines of the solar spectrum (1) in the neighbourhood of the horns, and (2) at the point of contact of the lunar disc with a sun-spot. The observations, he says, were made under the best conditions, but gave a negative answer to the first of these two investigations. With regard to the second he says that no change was noted until at the moment of the greatest phase when the lines of magnesium b^1 b^2 b^4 "appeared sharp and seemed to be accompanied on both sides with very fine lines reminding one of what in spectroscopy is known under the name of *persiennes*. C was terminated, as M. Spée says, "*en fer de lance*" penetrating the chromosphere.

BULLETIN ASTRONOMIQUE FOR APRIL.—In this periodical for the past month M. Haerdtl contributes some notes relative to some small inequalities of long period in the movements of the Moon, Earth, and Mars. The determination of the orbit of the periodical comet Finlay (1886 vii.) is the subject of a long article by M. Schulhof, but in this (to be continued in the next) he only limits himself to the ephemeris and the mean positions of the comparison stars, with copious notes giving the authorities, proper movements, and remarks. *Apropos* of the question of the variation of latitudes M. Boquet gives an interesting historical notice on the latitude of the Observatory of Paris, in which he recapitulates all the attempts made to fix the value of this important element. Now that we know that variations occur, it is most interesting to read the remarks of the authors of these various determinations at different times with respect to the discrepancies between the values. M. Yvon Villarceau for instance, from his observations in 1866 and 1867 says: "Quant à la mesure exacte de la latitude, nous ne voyons pas qu'elle puisse résulter des mesures faites aux Cercles muraux de Gambey et de Fordin." . . . .

GEOGRAPHICAL NOTES.

THE death of Mr. W. Cotton Oswell on May 1st, at the age of 75, removed a famous African-traveller and hunter whose name had almost ceased to be remembered by the general public. In his early life Mr. Oswell spent five years in South Africa hunting and exploring. His adventures were of the most thrilling kind, and the trophies he preserved in his house at Groombridge form a unique collection. He was associated with Livingstone in his earlier travels, and charged himself with the care of the waggons and the provision of food, while his companion planned the route and made scientific observations. In this way Mr. Oswell was with Livingstone at the discovery of Lake Ngami. Subsequently Mr. Oswell travelled and made collections in South America and elsewhere, but his extreme modesty prevented him from thrusting himself before the public, and he wrote nothing. His geniality in private life was as remarkable a feature of his character as his shrinking from all public appearances.

THE Canadian Government has decided to despatch an expedition, under the charge of Mr. J. B. Tyrrell, of the Geological Survey of Canada, to explore the barren ground northward from Lake Athabasca, a region which has not been visited by competent observers since 1772.

M. MARCEL DUBOIS has been appointed to the Chair of Colonial Geography, the foundation of which at the Sorbonne we intimated last year.

THE higher teaching of geography in England is not confined to the lectures delivered at the two ancient Universities. For some years Prof. C. Lapworth, F.R.S., has given courses on physical and political geography at the Mason College, Birmingham, which are this session attended by over eighty students. The complete course occupies two years, lectures being given twice a week; the syllabus is drawn out on thoroughly scientific lines, and while entirely original in treatment is comparable with the best instruction given in the same subject in German Universities.

ENGINEERING works of such magnitude as to be of geographical importance have been for some time carried out on the Alsatian slope of the Vosges in order to regulate the water supply for industrial purposes. A series of reservoirs, so large as to be described as artificial lakes, has thus been formed, and the rainfall of the district can now be utilised much more completely than was formerly possible.

THE FUNDAMENTAL AXIOMS OF DYNAMICS.

IN view of a discussion at the Physical Society of London on Friday, the 26th inst., it may be convenient if I anticipate future communications so far as to give in a brief or summary form the "Laws of Motion" somewhat as I propose to advocate their acceptance; not, however, entering into details, and not being specially careful about precise form of words, rather aiming at giving the general sense with the object of assisting discussion by abbreviating or summarising my paper in a few definite statements.

Notions derived more or less directly from sensations, and here accepted as understood without special definition.

Motion, Space (extent and direction), Velocity (including direction), Time, Stress, Force (including direction), Matter.

About all these there is much to say; some are more immediate sense-perceptions than others, but a detailed discussion of them verges on metaphysics, and is not an *essential* preliminary to a physical treatise. All that is *necessary* is explanation and illustration sufficient to render the terms intelligible. All that I shall say here is that by "matter" is meant primarily something tangible or resisting; that we experience "force" when we push a truck; that a thumbscrew gives us a notion of "stress": and that pushing a truck does also, if we attend to both hands and feet.

Remarks, Practical Assumptions, and Experiments.

There is no need to discriminate a force from a vector in a fundamental treatment, because all ideas about moment of force, angular momentum, and the like, belong to a consideration of the behaviour of a rigid body, which is an artificial agglomeration of connected particles: convenient, not fundamental.

But there are some assumptions and experiments needful to be made concerning the measurement of force more precisely than by our muscles.

(*Assumption* 1). That the weight of a given piece of matter at a given place is not liable to capricious change.

(*Assumption* 2). That two similar lumps of matter weigh twice as much as either.

(*Experimental result* 1). That strains of elastic bodies are proportional to the stresses within certain limits.

(*Experimental result* 2). That the frequency of a loaded elastic body, vibrating within the above limits is independent of amplitude.

(*Experimental result* 3). That in cases of impact there is one point whose motion is undisturbed by the blow.

Definitions, Simple Experiences, and Axioms.

(*Experience* 1). A stress consists of two forces.

(*Definition* 1). Acceleration (including direction) = dv/dt.

(*Experience* 2). Acceleration occurs in matter subject to an unbalanced force.

(*Axiom* 1). Without force there can be no acceleration of matter.

(*Experience* 3). The acceleration appears to agree with the force in direction, and is in some cases demonstrably proportional to the force. (A deduction from experimental result 2 above.)

(*Axiom* 2). The acceleration of a given piece of matter is proportional to the (effective or resultant or unbalanced) force acting on it, and is in the same direction.

(*Experience* 4). Stresses in a body do not accelerate it as a whole.

(*Axiom* 3). The two forces of a stress are always balanced.

[*Or otherwise* (after Experience 3).]

(*Definition* 2). The ratio of the force acting to the acceleration produced in a given piece of matter is called its "inertia."

(*Axiom a*). The inertia of a given piece of matter is unconditionally constant, and has no direction.

(*Remark*). Inertia is therefore taken as the most fundamental property of matter, and is used to measure its massiveness or "mass."

Definition 3). The centre of mass of a system is a point such that $\Sigma(m\mathrm{r}) = 0$; *or*, it is a point moving with speed v, such that $\Sigma(m)\mathrm{v} = \Sigma(m\mathrm{v})$.

(*Axiom b*). The centre of mass of a system is not accelerated by internal stresses, but only by one component of a stress whose other component acts on a body foreign to the system.

(*Deduction*). The two forces of a stress are always equal and opposite.

(*Remark*). A brief and convenient statement of Axiom 2, by help of Definitions 1 and 2, is $\mathrm{F}dt = m d\mathbf{v}$. Note that F and dv have necessarily the same sign; they are parallel vectors.

(*Experience* 5). Every force is one component of a stress; in other words, bodies can only mechanically act on one another (*i.e.* so as to affect each other's motion) by means of stress; or stress is essential to mechanical action.

(*Remark*). This might have been made part of Axiom 3, but it is really a distinct statement. Perhaps it should be stated as an axiom.

(*Axiom* 4). A stress cannot exist in or across empty space.

(*Deduction*). Therefore bodies (or any media) immediately acting on each other are necessarily in contact, and stress exists at the point of contact, where the normal components of their velocities (v) are identical.

(*Experience* 6). When stress and motion coexist, action occurs or activity is manifested.

(*Definition* 4). The scalar product of the two vectors Fv is called "activity."

(*Deduction*). The activities of two immediately acting bodies are equal and opposite.

(*Remark*). Elastic bodies under stress, and moving bodies with inertia, are found to be able to manifest activity, and are said to possess energy whereby they can do work on other bodies. Stress energy is called potential; motion energy is called kinetic.

(*Definition* 5). Work done $= \int (\text{activity})dt =$ energy gained or lost.

(*Remark*). There are two ways of regarding this quantity: $\int \mathrm{F}v dt$; namely either as $\mathrm{F}(v dt) = \mathrm{F}ds =$ change of potential energy, or as $v(\mathrm{F}dt) = v.m d\mathrm{v} =$ change of kinetic energy.

A body for which Fv is positive is losing energy; a body for which Fv is negative is gaining energy.

(*Deduction*). Since the activities of two immediately acting bodies are equal and opposite it follows by Definition 5 that energy lost by one is gained by the other; *i.e.*, that energy is simply transferred without loss or gain across the point of contact in the direction of the common velocity.

(*Axiom* 5). Energy which is not being actively transferred from one body to another remains unaltered in quantity and form.

(*Remark*). Energy which is being transferred from one body to another changes its form. The kind of transformation depends on the sign of dv with respect to the common velocity of the acting bodies at their point of contact.

If vdv is positive, energy is being transformed into kinetic; if vdv is negative, it is being transformed into potential; if vdv is zero, there is a mere flux or transmission of energy without transformation.

(*Deduction*). Since transference of energy is essential to activity it follows that only bodies which are able automatically to part with some of their energy, are able automatically to do work. In other words, automatically transferable energy is alone available or potential.

(*Experience* 7). The automatically transferable or potential energy of a body or system is liable to transfer and transform itself into kinetic. Hence

(*Axiom* 6). The potential energy of a system tends towards zero.

(*Experience*). Kinetic energy is only available when associated with appreciable or relative momentum.

The following statements may be made about the irregular and aggregate motion of particles called Heat.

(*Experience*). Heat will not flow from low to high temperature by mere conduction (as it could, for a time, if it possessed inertia, like water, air, or electricity). It can only flow from cold to hot by help of convection by matter or something else. Such flow is therefore not a cyclical or perennial process.

(*Deduction*). Energy of average temperature is useless for continuous work. In other words, the only available or potential portion of heat-energy, when dealt with in the aggregate, is that which a body is able freely to emit to colder bodies.

(*Definition*). The absolute temperature of a body is to its total heat-energy as the available fall of temperature is to its potential heat-energy.

OLIVER LODGE.

THE ROYAL SOCIETY SOIRÉE.

THE Royal Society Soirée on May 10 was in every way most successful. It was very numerously attended, and much interest was excited by many of the exhibits and by the demonstrations. In the following account of the exhibits we give a full account only of such objects as have not before been referred to in NATURE:—

Captain Abney, C.B., F.R.S., and General Festing, F.R.S., exhibited experiments on the extinction of light and colour.

Sir J. B. Lawes, Bart., F.R.S., and Dr. J. H. Gilbert, F.R.S., exhibited a series of photographs relating to the working of the Rothamsted Laboratory. In experiments on the growth of root-crops year after year on the same land, it was found that after a very few years of growth without manure, the root no longer developed the swollen character of the cultivated plant, but remain fusiform as in the uncultivated condition. The photographs strikingly show the same characters in roots grown in rotation without manure; also that mineral manures alone greatly favour the development of the swollen root, but that mineral and nitrogenous manures together do so in a much greater degree. The results further show how artificial a product is the cultivated root-crop, and how dependent it is on an abundant supply of food within the soil—nitrogenous as well as mineral. Indeed, details of the experiments afford conclusive evidence that it is quite fallacious to suppose that root-crops derive a large amount of their nitrogen from atmospheric sources by means of their extended leaf surface.

Three instruments for the study of Crystals were shown by Mr. H. A. Miers. (1) A goniometer by which crystals can be measured under liquids, or during their growth from solution. (2) A stage-goniometer by which small crystals or fragments can be adjusted and rotated under the microscope. It is here fitted to the stage of the petrological microscope designed by Mr. A. Dick. (3) An improved form of polariscope on the plan devised by Prof. W. G. Adams, F.R.S. The hemispheres which enclose the crystal section can in this instrument be accurately centred so that exact measurement of the optic axial angle is possible.

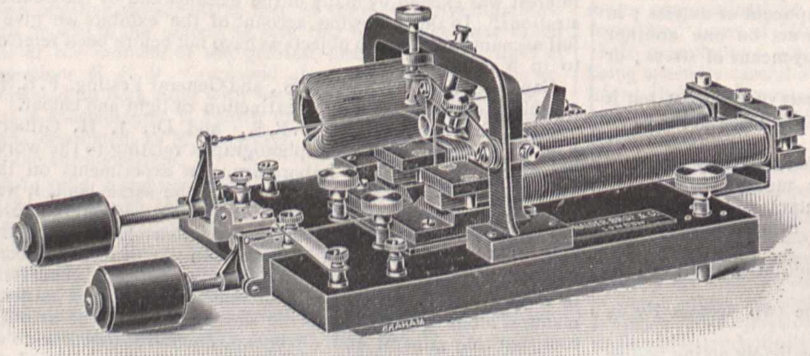
Prof. Rücker, F.R.S., and Prof. Thorpe, F.R.S., exhibited maps showing the forms of the true lines of equal declination, equal horizontal force, and equal dip in the United Kingdom for the epoch, Jan. 1, 1891.

Mr. A. A. C. Swinton exhibited high frequency electric experiments. (1) The filament of an ordinary 5 c.p. 100-volt lamp is caused to incandesce with current conveyed through the human body. (2) Sparks, evidencing a difference of potential of some thousands of volts, produced between the two hands of the same operator. (3) Luminous spiral produced in exhausted glass tube by molecular bombardment from wire spiral wound outside tube. (4) Some effects produced by high frequency discharges passing through semi-conducting substances, and striking liquids.

Sodium potassium high temperature thermometers, and specimens of the alloy, were exhibited by Mr. E. C. C. Baly and Mr. J. C. Chorley. These thermometers are filled with an alloy of sodium and potassium which is liquid at ordinary temperatures. Their range is from 0° to 620°C. (1,150°F.); the softening point of the glass, a specially hard kind, being about 650°C. The separate specimens of the alloy are exhibited to show its purity and its very remarkable surface tension.

Mr. Cecil Carus-Wilson exhibited the scotographoscope, for enabling lecturers to demonstrate with chalk in a darkened room. A compartment encloses a lamp so arranged as to cast a pure white light upon the interior surface of the sheet of specially prepared glass, which forms the front of the apparatus. In a darkened room, on removing the sliding screen, an intensely white surface is exposed, upon which chalks of any colour can be used in the ordinary way. Small chalk drawings easily seen at a distance of 100 feet or more, and they may be rapidly deleted by means of a damp sponge. The whole apparatus folds into a small compass for travelling.

Magnetic curve tracers, were exhibited by Prof. Ewing, F.R.S. The magnetic curve tracer exhibits the relation of magnetism to magnetising force in iron. A mirror, which is free to move both vertically and horizontally, receives two component motions: one (horizontal) proportional to the magnetising force H, and the other (vertical) proportional to the magnetisation B. The reflected light traces the characteristic cuve or B and H, exhibiting the influence of magnetic hysteresis. The instrument at work in the recess shows a cyclic process caused by periodic rapid reversals of magnetising force. A more recent form of the magnetic curve tracer is also shown (made by



Messrs. Nalder Brothers) which is arranged for the commercial testing of iron. The metal whose magnetic qualities are to be tested is made up in rods, which are readily inserted and removed. The rods which are shown are built up of narrow strips of sheet iron.

Prof. A. Smithells, B.Sc., exhibited experiments to demonstrate the structure of flames. (1) The separation of a non-luminous coal-gas flame into two combustion cones is effected by sliding a wider tube over the one on which the flame rests. The products of combustion can be aspirated from the intervening space. (2) Using benzene vapour instead of coal-gas, the transition from a simple luminous flame to a non-luminous flame is shown. The two cones of the latter are separated as before, and by a further addition of air the outer cone disappears, the complete combustion occurring in a single cone. (3) By introducing a spray of a solution of a copper salt, it is seen that the coloration of the flame occurs only in the outer cone where copper oxide is formed. (4) The cone flames are also separated by using a single tube. A platinum wire is pushed up axially till it touches the inner cone. On drawing it down, the inner cone is inverted and follows the wire.

Rev. F. J. Smith, M.A., exhibited an inductoscript. The inductoscript figures and pictures are made by placing the object to be reproduced in contact with an ordinary photographic plate, placed upon a conducting sheet of metal. The object and the plate are connected to the terminals of an induction coil or other source of electricity, for a fraction of a second, and then developed in the usual manner. Several of the pictures shown were produced on plates which had been exposed to full daylight. The pictures marked B were produced by the same method on bromide paper. Non-conductors such as wood blocks are coated with a surface of plumbago before being operated on. The best results are obtained by conducting the process in oxygen gas under a pressure of about two atmospheres.

Platinum thermometers and pyrometers, compensated resistance boxes and galvanometers, compensated barometer and air thermometer, exhibited by Mr. H. L. Callendar; a series of sections illustrating the seasonal distribution of temperature in sea-water lochs, exhibited by Dr. Hugh R. Mill; a portable hydrogen oil safety lamp, adapted for illumination and delicate testing in air containing any kind of inflammable gas or vapour, exhibited by Prof. Frank Clowes, D.Sc.; tuning forks worked electrically, a portable photometer, a table polariscope, exhibited by Sir David Salomons; high tension apparatus, exhibited by Sir David Salomons and Mr. L. Pyke; electrical apparatus, exhibited by Major Holden.

The Marine Biological Association exhibited marine invertebrata from the Plymouth area. Selected specimens of crustacea decapoda, and mollusca opisthobranchiata, including many rare species, and illustrating the richness of the Plymouth fauna.

Dr. G. H. Fowler exhibited specimens of oyster shells. The specimens illustrate:—(1) The rate of growth of the oyster. (2) Natural varieties of the shells. (3) Modifications of a variety bred under new conditions.

Prof. Weldon, F.R.S., exhibited diagrams showing the frequency of variations in the size of certain organs of crabs. The diagrams are based on measurements of portions of the carapace and other parts of *Carcinus mænas*. The organ to which each diagram refers is indicated in the central drawing of a crab. Each diagram is based upon measurements of 1,000 individuals, and the size of the organ measured is indicated (as a percentage of the body length) on the base-line of each. The vertical ordinates of the black curve show the number of individuals having the organ measured of the given magnitude, and the red curve is a probability curve.

Spectra of the flame from a Bessemer converter, exhibited by Prof. W. N. Hartley, F.R.S. The photographs comprise the solar spectrum intended for reference, together with spectra of the Bessemer flame taken at consecutive periods of the "blow" as indicated by the time during which the plate was exposed in each case. The flame spectra will be seen to be composed of (1) a continuous spectrum due to carbon monoxide; (2) a band spectrum belonging to metallic manganese; and (3) a line spectrum principally belonging to iron. Lines of potassium, sodium, and manganese are also present. Taken at the Crewe Works of the London and North-Western Railway Company, by permission of Mr. F. W. Webb, January, 1893. Enlarged ten diameters by the Autotype Company.

Prof. J. Norman Lockyer, F.R.S., exhibited the photographic spectra of some of the brighter stars.

Mr. Isaac Roberts, F.R.S., exhibited five original negatives and enlarged photographs of nebulæ and clusters of stars, taken with the 20-inch reflector by the exhibitor.

Some species of butterflies, illustrating protective mimicry were shown by Colonel Swinhoe. Mimetic forms of the nymphalid genus Hypolimnas in India, Malayana and Africa, showing the various phases of development of mimicry in two widespread species of the same genus; also mimetic resemblances to different protected species in the females of *Euripus halitherses*, &c.

The Zoological Society of London exhibited specimens of lepidopterous insects bred in the insect house of the Zoological Society in London. Four cases containing specimens of *imagines* or perfect insects, raised from *chrysalides* or pupæ in the Zoological Society's insect-house in the season of 1892. They belong chiefly to the silk-producing moths of the family Bombycidæ, and to the diurnal lepidoptera or butterflies.

Remains of extinct birds from New Zealand and the Chatham Islands (off the coast of New Zealand), exhibited by Mr. H. O. Forbes. The exhibit consisted of the chief portions of the skeleton of *Aphanapteryx Hawkinsi* (Forbes), a genus of rails known hitherto only from Mauritius, and of *Palæocorax Moriorum* (Forbes), a large raven, a form not otherwise known in the region; portions of the skeleton of a large *Fulica*, and of a species of swan, now extinct, from the Chatham Islands; a part of the skull of a large Auserine bird allied to *Cereopsis*, found associated with moa remains in a bog in New Zealand; the tibia of a new species of *Cnemiornis*, an extinct giant goose

(*C. gracilis*, Forbes), and the limb bones of three species, belonging to a new genus *Palæocasuarius* (Forbes), of the *Dinornithidæ*.

Dr. D. Sharp, F.R.S. exhibited some ants and their sound producing organs. The sound-producing organs of ants consist of very fine parallel lines engraved on a portion of the outer surface of the chitinous skeleton and of a scraper or very fine edge. Great delicacy of movement may be given to the latter instrument by means of a ball-and-socket joint.

Sections showing the microscopic structure of certain fossil cryptogamic plants from the coal-measures, exhibited by Prof. W. C. Williamson, F.R.S., and Dr. D. H. Scott; white corpuscles of the blood and lymph under the microscope, exhibited by Mr. W. B. Hardy and Dr. A. A. Kanthack; maps and photographs illustrating the Sandgate Landslip, exhibited by Mr. W. Topley, F.R.S., and Mr. R. Kerr, F.G.S.

Mr. Edward Matthey F.C.S. exhibited form in which antimony separates from bismuth at a temperature of 350°C. The specimens are those of the film as removed from the surface of the melted antimonial bismuth. They consist of antimony oxide, containing about ten per cent. of bismuth.

Two compact voltaic batteries of zinc and platinum, were shown by Dr. G. Gore, F.R.S.

Major P. A. MacMahon, F.R.S., exhibited peramutational tesselations. A new method of obtaining designs for tesselated pavements, based upon the property possessed by the twenty-four different isosceles right-angled triangles derived by permuting four designs in all possible ways upon the sides.

Mr. E. Wethered exhibited photo-micrographic lantern slides, illustrating the micro-organisms in limestone rocks. The slides especially illustrate the remarkable structure known as *Girvanella*.

Lord Armstrong, C.B., F.R.S., exhibited experiments to show the nature of the electric discharge in air and water. The experiments will all be exhibited in action on the screen of the electric lantern, and will include the transfer of a cotton string from one vessel to another by means of a current of water flowing within another under the influence of electricity. Various dust figures will also be formed and similarly shown, displaying the nature and effects of the electric discharge in air.

Preparations and photographs demonstrating the action of solar and electric light on the spores of bacteria and fungi, exhibited by Prof. H. Marshall Ward, F.R.S.

THE INTERDEPENDENCE OF ABSTRACT SCIENCE AND ENGINEERING.

ON Thursday evening, May 4, the first "James Forrest" Lecture was delivered at the Institution of Civil Engineers, by Dr. William Anderson, F.R.S. The subject was "the interdependence of abstract science and engineering." After briefly explaining the origin of the lecture, Dr. Anderson proceeded:—The theme which has been prescribed is "The Interdependence of Abstract Science and Engineering," and I imagine that the subject has been chosen because of an uneasy feeling, which possesses many thoughtful men, that this country is not keeping pace with its neighbours in engineering progress, and that we shall, in the future, have to pay more attention to abstract science and its application to practice, than we have been, so far, in the habit of doing.

With rare exceptions, in this country, has there been even a slender amount of theoretical knowledge imparted to various grades of employment; it is only during the last few years that Science Colleges and technical education in schools and People's Palaces, are beginning to bring our operatives up to the level of our foreign friends, but, unfortunately, too late to retain that preeminence which we at one time could claim, and, I fear, placed too much confidence in; and moreover, a new danger has arisen in the circumstance that popular scientific education has taken a one-sided direction, that of mechanical and technical knowledge alone, so that, though the operative approaches his work with increased intelligence, he remains unfit to reason out the great economic problems on which his own welfare and that of the nation depend.

It is a matter of extreme surprise to me that so little attention is paid to the science of Political Economy, that not only the mass of the people, in whose hands the voting power now lies, but even, in a great measure, the representatives whom they elect, have no systematic training in, and are grossly ignorant of, the principles which lie at the root of national prosperity. The further misfortune follows that politicians of the highest position do not scruple to trade on this ignorance, or pursue a course which, in its consequences, is as bad—being ignorant themselves they strive to lead the ignorant, and set the operative against his employer and against society in general. The cheapness of newspapers, their wide diffusion, and their blind, not to say reckless advocacy of popular fallacies acting on the ignorance, prejudices, and discomfort, if not suffering, of the operative classes, are giving enormous power to trade organisations, whose avowed object it is to improve the earnings and social standing of the operative at the expense of, or at any rate without regard to, the interests of every other class in the community, and this is to be accomplished not by encouraging education, not by advocating thrift and temperance, not by urging the workman to improve his mechanical dexterity, the thoroughnesss of his work and the amount which he produces, but by holding out visions of shortened hours of labour, by compelling a minimum of pay which will enable him to live in comfort, of systematically restricting the amount of work done by each individual, even in the shortened day, all under the fatal illusion that by such means a greater number of men will find more remunerative employment.

The employer is usually credited, by the trade leaders, with accumulating wealth without effort, risk, or anxiety, by the slavish labour of his operatives, while the proofs to the contrary, so easily to be obtained in the slender dividends declared by most industrial enterprises, and in the records of the Bankruptcy Courts, are steadily kept out of view.

There would be no fault to find with the new class of professional agitators, who live by the discontent which they foment, were they, and the Unions which they manipulate, to contribute in the smallest degree to the obtaining of that work and of those orders, in the execution of which the wage-earning portion of the community have their being. This, the most difficult part of every commercial enterprise, is left to the much-abused capitalist, so that the absurd and impossible system is fast asserting itself, that professional skill, mercantile ability, and capital, shall obtain the work, and run all the risk of design, execution, and financial security; but that work shall be carried out according to rules which self-constituted and perfectly irresponsible bodies choose to impose. The smallest acquaintance with the principles of political economy would demonstrate that such methods must end in ruin, that they are utterly incompatible with our policy of Free Trade—a system which is perfectly reasonable and proper if thoroughly carried out, and which certainly never contemplated the protection of one particular class, and that, not by edict of the State, but at the bidding of self-constituted tribunals whose claims amount to this:—that there shall be free trade in all products which the operatives require to buy, but the strictest protection as to all that they have to sell, namely their labour, and whose ultimate methods are violence, and the coercion of all who differ from views which many intelligent but timid workmen know to be at variance with the true interests of their class.

Under all this lies the socialistic idea of equality in the condition of every member of the community, an idea which political economy demonstrates to be utterly Utopian and impossible. Since the creation of mankind the differences in social position and in material comfort which follow naturally from the endless variations of mental and bodily powers in men, have existed, and, in spite of many abortive attempts, more or less violent, to establish equality, will exist for ever; for it seems to me that the doctrine of Carnot with respect to heat-engines applies by analogy to the question of national prosperity. To obtain mechanical power from a source of heat there must be a fall of temperature, and the greater that fall is the more efficient will the engine be—a dead level of temperature simply means extinction of energy and of life. To ensure active trade and prosperous manufactures there must be a fall of money or of its equivalent from the wealthy to the comparatively poor, the one class is absolutely essential to the other; the prosperity of the community is bound up in the existence of these differences, and a dead level of wealth would be a dead level of poverty, which would end, as a state of uniform temperature must end, in absolute stagnation and death.

However much we may regret the inequality which exists in the distribution of wealth and comfort, it is just as much a law of nature as the unequal distribution of warmth, of sunshine, or of rain, and seems to me to follow naturally and inevitably from the endless variations in the physical, moral, and mental powers of human beings, and therefore to be as unalterable at the bidding of man as these attributes are. It only remains for us to recognise the fact, to make the best of it, and to avoid the gross wickedness of attempting to delude the poorer and more ignorant members of the community by incessant representations that it is the greed and selfishness of the wealthy which keep them low.

If the so-called "working man" be the embodiment of all that is needed for the industrial prosperity of a country, and if the possession of capital and the far wider consequence, the existence of credit, be a crime, why does he not arise in his strength and exhibit the faculties of combination which are so well illustrated in the trades unions, and establish engineering works and manufactories, or undertake engineering enterprises from which he will be able himself to reap the golden harvest which the capitalist and the shareholder are supposed to gather, and who thereby excite his envy and arouse his hatred.

In deference, I presume, to the immense numerical importance of the operative classes, politicians are vieing with each other in supporting the impossible claims put forth—claims which, if conceded, will only precipitate the ruin of the class they profess to benefit, and which already is the form of what may be termed benevolent legislation in favour of the operative, is heaping up elements of cost which our productive energy is unable to bear. The absurd cry that manual labour is the sole source of wealth has been well combated by that acute reasoner, Mr. Macfarlane Gray, who, in a recent discussion on the labour question, happily compared the body politic to a tree. The popular belief is that plants are nourished through their roots, which for that reason are believed to be the all-important parts, while the leaves are mere ornaments, enjoying the upper air and sunshine and profiting by the work done underground. But a juster knowledge, one of the fruits of abstract investigation, tells us that the roots are mainly useful in holding the tree erect, and have comparatively little to do with providing the materials for building up its structure. It is the leaves which form the great laboratory in which the main components of the plant are extracted from the region where superficial observers would least expect to find them—namely, from the atmosphere. He compares the roots to the operatives' part of the community; the trunk and leaves to the monetary, the scientific and the commercial part which drew from far and wide that which is necessary to keep the growth advancing and maintain it in health. The roots may just as well claim to be the sole sources of life in the tree as the operatives may claim to be the only producers of wealth, and conversely the leaves could, with as much reason, consider themselves as the only essential portion of the plant as the merchant or the capitalist claim to be independent of the operatives. Each grade in the body politic is essential to the other; it is an axiom that there can be no degrees of comparison between essential parts; and those who, from ignorance or from interested motives, persistently preach the doctrine of the superior importance of the "masses" over the "classes" are inflicting a deep injury on the prosperity of the country, and especially on those whom they so grossly flatter.

Nothing, save bitter experience, will alter the course of events. It seems to be the fate of peoples to attack social problems from the wrong end, to solve them by the painful and dilatory process of trial and error, rather than by means of investigation based on first principles. And this method is commonly applied to engineering problems also. Random trials, as a rule, are the methods by which great results have been achieved, while the application of the scientific principles involved have been left to other heads long after the results sought have been attained at much needless cost, and by much unnecessary expenditure of labour and of time.

It is not often that a genius of the order of James Watt rises in the mechanical world. Up to his time the "fire-engine," as it was most properly called, was being slowly developed without any exact knowledge of the properties of the agent by means of which the heat generated by the combustion of fuel was converted into work, and this in spite of the circumstance that such a master mind as that of Smeaton had been directed to perfecting the new method of utilising the potential energy of fuel, and of applying it to engines of large power, and on an extensive industrial scale.

The lucky chance which presented itself of having to put in order a working model of a Newcomen engine illustrates in an interesting manner how, in pursuance of his business, he quickly executed the necessary repairs and alterations, and afterwards, at greater leisure, attacked the problem which the failure of the model presented, from the theoretical side, but soon found that the then state of knowledge did not afford the means of explaining the failure, and compelled him to set about the determination of such elementary data as the specific volume of steam, the latent heat of evaporation, and the law of tension of steam under varying temperatures. In the astonishingly short period of two years, and with the rudest and cheapest apparatus, he had furnished himself with the abstract knowledge required for explaining in a definite manner the action of the steam engine, and he had no difficulty, as soon as his theoretical ground was sure, in determining what mechanical arrangements were necessary to realise the conditions imposed by science. From investigations apparently of an abstract or non-practical character, sprung at once the separate condenser, the closed cylinder and the equilibrium working of a single-acting engine, the steam jacket, the air-pump, the theory of expansive working, the function of the momentum of the moving parts, and the exact calculations based on first principles by means of which the proportions of engines could be fixed, and the quantities of steam, water, and of fuel calculated. Watt, of course, was a born mechanic, as well as a seeker after physical knowledge. The workshop in his house near Birmingham, happily preserved to this day as he left it, shows that his mind was ever bent on mechanical contrivances which his own hands were skilful enough to carry out; his valve-gear, the stuffing box, the parallel motion, the governor, are all instances of that happy blending of mechanical skill and of scientific research which must ever mark the qualifications of a great mechanical engineer.

A contrast to Watt's achievements is the singular history of the development of iron and steel bridge building, which necessarily followed the introduction of railways. Watt felt the want of first principles by which to shape his actions, and set about discovering them; but the principles which underlie the determination of stresses in braced structures, such as roofs and frameworks of various kinds, as well as those in solid bars subjected to the action of transverse forces, have long been known; and early in this century Navier made them the subjects of lectures at the École des Ponts et Chaussées, yet engineers in this country seem to have been but dimly aware of them, or, at any rate, to have made little use of the knowledge which was at their disposal. It is difficult, from the published histories of such enterprises as the Conway and Britannia bridges, to arrive at any conclusion as to the extent of knowledge, or rather ignorance, which existed among engineers before these works were commenced. It is sufficiently evident, however, from the long series of purely tentative experiments by which the proportions of the Conway and Britannia bridges were determined, as well as from the singular vagaries to be noticed in the smaller bridges of that day, that only the haziest ideas of the disposition of stresses, and of the functions of the component members of girders existed.

In the experimental investigations of the time, the function of the web or vertical member of a girder was completely ignored, for it was looked upon merely as the means of keeping the top and bottom flanges in their relative positions, while the essential difference in effect of a uniformly distributed load, or of a rolling load, as compared with a load concentrated at the centre, on the vertical member of a girder, and even on the flanges, appears to have been overlooked till made evident by the results of experiment. Yet the principle that a force cannot change its direction unless combined with another force acting in a direction inclined to it, was perfectly well known, and should have led to the discovery that it is only by diagonal stresses in the vertical members that the load resting on a beam can be transmitted to the abutments; that the stresses due to loads concentrated at the centre were very different to those arising, both in the vertical web and in the flanges, from the action due to a load distributed in a given manner along the top or the bottom flanges, and that a rolling load would produce effects peculiar to itself.

The girder with diagonally braced webs, or the lattice girder, as it is commonly called, appears to have had its origin in Ireland; at any rate it was in that country that it received its earliest and chief development; and in the hands of Wild, Barton, Bow, and Stoney, the true principles began to assert themselves, and Mr. Barton's Cusher River bridge, of 70 feet span, on the Great Northern of Ireland Railway, was probably the first example of a lattice girder in which the cross-sections of the members of the webs as well as those of the flanges were correctly proportioned to the stresses imposed by a rolling load. This comparatively small bridge was followed by the Boyne viaduct at Drogheda, which must ever rank as a signal illustration of the successful application of abstract principles to a great work by men who were capable, not only of appreciating them, but of following their guidance in a practical manner.

The wrought-iron portion of the viaduct consists of three spans, the main girders of which are continuous; and the points of contrary flexure in the middle, and larger span, were determined by direct calculation, the correctness of which was demonstrated in the actual structure by setting free the plates of the flanges at the points indicated, and by observing the opening and closing of the plates so disunited when the land ends of the girders formimg the side spans were raised or lowered.

Mr. Wild appears to have been the first to demonstrate correctly the distribution of stresses under any disposition of load in the Warren girder, a form of beam in which the web is composed of a single system of diagonal bracing inclined at an angle of about 60°. In the museum of Trinity College, Dublin, there has existed since, I believe 1854, a model of a Warren girder, 12 feet 6 inches long and 12 inches deep, in which the tension members both of the flanges and diagonal bracing are so arranged and articulated that any one section can be taken out and a spring balance inserted, by means of which it can be demonstrated that the stresses calculated for any disposition of load do actually arise.

The history of scientific research teems with instances of discoveries which at first seem to have had no practical value, but which nevertheless have ultimately proved to be of the utmost importance to the engineer. For example, the changes of temperature which occur in many chemical reactions were merely noted at first as interesting accompaniments to such reactions; but, by degrees, it was perceived that the amount of heat evolved or absorbed in each change was a constant and definite quantity, capable of exact measurement, and in process of time the thermal values which characterised a vast number of chemical changes were determined, and are now considered of cardinal importance in many industrial operations, and constitute the science of thermo-chemistry, and render it possible to judge of the efficiency of a boiler, for instance, when the rate of fuel combustion and that at which the water was heated or evaporated were known, by calculating the proportion which the heat imparted to the water bore to that produced by the combustion of any fuel of which the chemical composition had been ascertained, and from which the heat capable of being developed could be calculated by general rules.

One practical effect of the exact knowledge which every competent engineer now possesses on this subject, or can easily obtain, is that inventors have ceased to squander their time and their means in seeking for impossible high boiler duty, and the public is no more entreated to try contrivances which are to save at least 50 per cent. of the fuel they use, because inventors know that the testing of boilers is now usually carried out by experienced and educated men, who, by very simple and inexpensive trials, obtain the data by means of which they can calculate with certainty how much scope for improvement actually exists.

Still more remarkable perhaps is the application of thermo-chemistry to the complicated reactions in the blast and regenerative furnace, and the valuable conclusions arrived at in consequence by such thorough and patient investigators as Sir Isaac Lowthian Bell, Sir William Siemens, Charles Cochrane, and others who have succeeded in equating the heat-units resulting from the oxidation of fuel to the ultimate thermal results of the decomposition of the ore and fluxes, showing thereby the limits of economy which the ironmaster may hope to reach, and the proportions of the furnaces in which his expectations may be realised.

No less valuable have been the fruits yielded by the discovery of the great law of the Conservation of Energy, and by the recognition of the fact that, though energy cannot be destroyed, it may be made to assume various forms, and may be rendered either dormant or active. The sun's rays, aeons of ages ago, during the dense vegetation which characterised the period of the coal measures, expended their energy in tearing asunder the carbon and oxygen of the carbonic acid distributed through the atmosphere, and in storing the carbon, thus endowed with potential energy, in the deposits whence we now derive our coal supplies. By suitable arrangements this dormant energy is quickened into that quality of motion which we recognise as heat, and which, setting into sympathetic vibrations the material of the furnace-plates and smoke-flues of boilers, operates on the surrounding water, the molecules of which, under this influence, assume the more extended movements of the highly elastic substance which we know as steam. The products of combustion, on the one hand, are restored to the atmosphere, their remaining store of heat is slowly dissipated, while the carbonic acid gas produced in combustion is again ready to present itself, in the green leaves of plants, to the decomposing action of the sun, and by that means the carbon and the oxygen become once more sources of heat. The steam produced, on the other hand, communicates its molecular motion to external bodies in various heating operations, in the visible motion and force of the steam-engine or into the slower dissipation through space or over the earth, whereby it is again condensed to water and returned to its normal condition, while the energy, for the exhibition of which, Carnot has taught us, steam was the mere agent, becomes transformed into masses of water lifted, into air compressed, into electrical currents generated, into mechanical work done, or into the heat developed by friction; but the general tendency is towards dissipation under the form of heat into space, the waste being made good by the stores of heat poured on to our planetary system by the huge and mysterious body which is its centre.

But modern investigators, and, most of all, engineers, are not content with vague statements such as I have just made; they hold with the motto of the ancient Society of Civil Engineers, "Omnia in numero pondere et mensura," and they are therefore greatly indebted to Rumford, Carnot, Davy, Mayer, and Joule, who not only showed that heat was a "mode of motion," but determined by tedious and delicate experiments its mechanical equivalent.

And what is now the result?

When examining heat-engines or other applications of heat in the arts, the engineer collects the apparently aimless work of half a century, and of many minds, and finds himself able to construct a balance sheet by which he can show on the Dr. side, to a fraction, the quantity of heat he has received, and on the Cr. page, with astonishing precision, the manner in which that heat has been expended. This method of treatment is not only lucid, but it is self-checking, and it points out exactly how much heat has been uselessly dissipated, and consequently in what direction improvements may be made, and it indicated further, the limits within which it is alone possible to make advances in economy.

These general principles apply even to the conversion of heat into the work done in the bore of a gun. The enormous pressures which require to be developed in order to impress high velocity on the projectile in the necessarily limited length of the barrel, the shortness of the time of action, and its violence, render it extremely difficult to obtain accurate and trustworthy records of pressures along the chase of a gun by direct methods; but by invoking the aid of the chemist and of the physicist in first ascertaining the properties of the explosive, that is to say, the specific volume of the gases, the quantity of heat evolved during combustion, and the specific heat of its products at high temperatures, it becomes possible to calculate curves of mean pressure which will account for the energy imparted to the projectile and to the expelled gases, although the question of abnormal local pressures, due apparently to the mode of ignition of the charge and the rate at which explosion is propagated through it, will not be revealed. This process is made the easier, in the case of smokeless explosives, because the products of combustion are wholly gaseous and retain that condition till expelled from the bore.

One of the loftiest of abstract conceptions relating to the structure of the universe, the product of many acute minds of this century, is the imagining of a substance of infinite tenuity but of immense elasticity, which permeates all space and every substance. It cannot be seen, or felt, or weighed, its composition is unknown, it cannot be pumped out of a closed vessel, it does not appear to offer any resistance to the motion of planetary bodies, and its existence is only made manifest by its property of transmitting chemical rays, light, radiant heat, electricity, and probably some more recondite forms of energy, at enormous velocity from the remotest regions of the universe and by means of vibrations the nature of which, the astounding frequency and minute pitch, have been determined by mathematicians. It is pardonable in human beings to disbelieve in the existence of the luminiferous ether, even though the profoundest thinkers and most successful workers of the present day may have all the conviction of Lord Kelvin, who has declared that "it is the only substance that we are confident of in dynamics, the one thing we are sure of is the reality and substantiality of the luminiferous ether!"

But what has the Engineer to do with such speculations, and what does it matter to him how light and heat are transmitted from the sun or from the stars, or by what mechanism heat, magnetism, and electricity are diffused over the earth? This question is being answered already in our daily practice, and is destined, no doubt, to receive fuller and more convincing response as time rolls on. I will give one or two instances. The study of the spectrum produced by the passage of light through triangular prisms has revealed the fact that the ordinary rays of white light are of a complex nature, that only a portion of them are discernible directly by the sense of sight or by that of feeling, while the ultra-violet rays can only be seen in their action on Uranium glass, or in the chemical decomposition they produce in certain substances. But, further, the spectrum viewed by modern instruments is found not to be continuous; it is crossed by dark, by light, and by coloured bands, which the patient researches of Fraunhofer, Kirchhoff, Huggins, Norman Lockyer, and others, have shown by their position, thickness, or colour to characterise certain glowing substances, and by comparison with the spectra produced by heated terrestrial solids and gases, it has been proved that many of the elements in the sun and in the stars are identical with those with which we are familiar on this earth, and this knowledge has served in a striking manner to confirm the correctness of the nebular theory as to the origin of our planetary system.

Not only have a large number of terrestrial elements been discovered in the sun, but the spectroscope has revealed, to a large extent, the order in which they are arranged on the sun's surface, and this leads to the conclusion that at one time a similar order prevailed on the earth, and therefore throws some light on the deep geology of our planet.

One of the practical outcomes of these discoveries has been the theory of Mendeleeff on the origin of petroleum, a theory of the utmost importance to the human race, and to our country in particular, in view of the inevitable exhaustion of our coal supplies, for it asserts that petroleum is the product of the action of water on the carbides of metals at high temperatures at no very great relative depths in the crust of the earth, that this production is continually in progress, and that deposits thus actually forming may be reached in many places by sufficiently deep borings; and in view of recent progress in mechanical skill, it certainly would be rash to say that borings of immensely greater depth than any that we are as yet acquainted with will never be made, for if accumulated evidence as to the correctness of Mendeleeff's views together with the ever-increasing cost of fuel, shall hold out hopes of success, enterprising men will be found ready to embark their means in undertakings, the risks of which would not seem to be more formidable than those which surrounded the laying of the first Atlantic telegraph cable, and the rewards of success in which would be incomparably greater.

The researches of Roberts-Austen, of Osmond, Le Chatelier, and others, are slowly, but it is hoped surely, establishing laws by which the relative atomic volumes of ingredients will become a guide to the nature of their mutual interaction, and it seems probable that spectrum observations which are of such value in gauging the purity of the materials dealt with, will come in aid and in support of the indications given by automatically traced curves of rates of cooling, which have given such a deep meaning to the phenomenon of recalescence, a property of iron and steel which for many years remained a mere laboratory curiosity.

Many bodies, including metals and their alloys, may exist in more than one form; sulphur, for example, assumes two allotropic states, but at ordinary temperatures and in a comparatively short time the one condition passes into the other Mr. Addenbrook has recently prepared an alloy of aluminium. and nickel, which when freshly made possesses considerable tenacity, but which, after a few hours, crumbles into powder. The researches of Osmond seem to show that pure iron also can exist in two states—one very hard, the other soft, and it is more than probable that these states merge into each other under certain conditions of heating or cooling, or under the influence of foreign substances. There can be no doubt that steel also, in course of time, undergoes molecular change at ordinary temperatures, and possibly under the influence of strains produced by internal stresses due to unequal rates of cooling. It is a common opinion, based on experience, that tool steel should not be used as freshly made, but should be kept some months, and the same precaution applies to dies used in coining and similar operations, and to armour-piercing shot, both of which, having been hardened by necessarily unequal and rapid cooling, either accommodate themselves to the stresses engendered by slow changes in the motion of the molecules, or fail spontaneously even after months of repose. Glass undergoes similar changes, and generally materials which have been severely strained either by the external application of force, or by heating, will only gradually recover their normal condition. This has been beautifully demonstrated by Prof. Hughes, with the aid of his induction balance, on specimens of the narrow steel ribbon used in the manufacture of Longridge wire guns. A number of specimens recently submitted to him showed a remarkable uniformity of structure, but when heated to only 100° and examined immediately on cooling to the normal temperature, a distinct change was observable, yet after a few hours' rest the material returned to its normal state. If such changes are measurable in ribbon $\frac{1}{4}$ in. × $\frac{1}{16}$ in. in cross section, what may not be the molecular conflict in large masses? These may be produced by alternations of stresses as well as by changes of temperature, and point to the necessity of assisting the molecules and atoms to adjust themselves, or to return to a normal condition by raising the temperature of the substance to about the point indicated by *b* on Chernofi's scale, below which no change in the nature of crystallisation takes place, no matter how slowly the mass is allowed to cool. This principle is recognised in many ways in the arts. In drawing wire or in solid drawn metal-work, such as tubes and cartridge-cases periodical annealing must be resorted to; moreover, experience has shown that crane-chains, for example, should be annealed from time to time if they are to be used with safety; and Mr. Webb has adopted, with the best results, the plan of treating in a similar manner the moving parts of his locomotives after they have run a certain number of miles.

I feel convinced that the frequent disasters with screw propeller shafts, especially after they have been some time in use, arise from the failure to recognise the practical bearing of the tendency to molecular change under the influence of strain and temperature. A propeller shaft is subject to constant variations of stress due to the action of the cranks of the engine, to similar variations caused by the inertia of the screw, and again to a totally different set of stresses which may often be alternately tensile and compressive, due to the wear of the journals and to the working of the hull. The remedy, I feel convinced, lies in the periodical annealing of the material which must of necessity be so hardly used.

I think that it is now generally acknowledged that the luminiferous ether is also the medium by which electrical energy is transmitted by some kind of vibratory motion; hence the ease with which heat or mechanical work is transformed directly into electric currents in the thermopile, or in the frictional electrical machine, and the reasonableness of the great generalisation that we are living on a huge magnet—the poles of which are not far from coinciding with the poles of the earth.

Any one who doubts the value of abstract science should study the construction of the mariners' compass, and especially in the improved form introduced by Lord Kelvin; let him compare the blind groping after correction for the local attraction of the ship with the beautiful and simple theory which has rendered that correction not only easy but readily adapted to changes in the ship's position in the world; he will find that there is not a more striking instance of the profoundest abstract knowledge blended with the power to turn it to practical use, than in this and in so many other labours of the distinguished man whom I have named more than once, and whom this institution is proud to number among its honorary members.

I would now draw your attention to a startling consequence of the undulatory theory in the power which exists of exercising influence, by what is termed induction, at great distances. Animated by the conviction that electric energy was transmitted in the same manner and by means of the same all-pervading medium as radiant energy, and that the distance to which its effects would reach should be unlimited, though the appreciation might be a question of the delicacy of instruments, Mr. Preece has succeeded in sending messages by Morse signals across the Bristol Channel between Lavernock and Flatholme;

a distance of over three miles. The electro-magnetic disturbances were excited by primary alternating currents, having a frequency sufficient to generate a low musical note in a telephone, in a copper-wire 1237 yards long, erected on poles along the top of the cliff on the mainland. The radiant electro-magnetic energy was transformed into currrents again in a secondary circuit of 610 yards long, laid along the island parallel to the first and at a distance of 3·1 miles; the messages were read off on the island through the instrumentality of the induced currents.

Any one who has meditated deeply on the nature of the luminiferous ether and on its universal presence has probably felt that it must also be concerned in the action of the human brain. The mechanisms of the "five gateways of sense" have been worked out by anatomists and physicists, but their researches are incompetent to declare how the impressions sent along the nerves at last reveal themselves as images or perceptions in the mind. Lord Kelvin has discoursed on this matter; he has suggested the existence of a magnetic sense, and has shown that the mind may be influenced independently of the recognised organs of perception. There are undoubtedly occult phenomena which can only be accounted for by the supposition that one mind can interact upon another, even as Mr. Preece's parallel wires acted on each other.

Setting aside the immense amount of calculated delusion and imperfect observations which has characterised animal magnetism, clairvoyance, &c., though probably not more than astrology, necromancy, transmutation of metals, and other delusions, hampered the early advance of physical and chemical science, there still remains a substantial amount of authentic fact on which argument may be founded. Prof. Oliver Lodge drew attention to the matter in his Presidential Address to section A at the meeting of the British Association in Cardiff in 1891, and in the opinion of that acute investigator the subject seems to deserve the attention of scientific societies.

It is less than fifty years since the nature of epidemics and the mode of their propagation seemed to be beyond the reach of human comprehension, and when Pasteur commenced his classic investigations into the causes of fermentation and of contagious disease, no one, I presume, thought that such an abstruse study as bacteriology could ever be of the least interest to engineers, nor would they have thought that the controversy relating to spontaneous generation, which raged so fiercely only a few years ago, could have influenced the science to which they were devoted.

But the triumphant demonstrations of Pasteur, of Lister, of Burdon Saunderson, of Tyndall, and of many other workers at home and abroad have shown that there is no such thing as spontaneous generation; that zymotic diseases, those scourges of animal and vegetable life, are caused by living organisms whose modes of propagation and of travel are being eagerly studied, and are day by day being better understood; they have shown that we are no longer fighting at random against an unknown and covert enemy, but are face to face with a subtle foe, whose tactics we are rapidly learning to understand. We have discovered that his best allies are to be found in the carelessness of his victims as to cleanliness, to drainage, and water supply, and that his most formidable enemy is the engineer, who, being guided by the abstract investigations of the biologist and the chemist, can select with certainty the most fitting source of potable water, and can get rid of the sewage of centres of population, not only without inflicting injury on the surrounding community, but very often actually benefiting them by removing existing sources of pollution and by increasing the productiveness of the soil.

But not alone in sanitary matters has bacteriology produced profitable results; it may truly be said that the great industries of brewing, of wine and vinegar-making, and many other manufactures, have been placed on a sound footing by the knowledge we now possess of the occult action of ferments and of bacteria; and even in agriculture the true nature of the operations which take place in soil, by which the nitrogenous food of plants is rendered capable of assimilation, is one of the triumphs of the research of these our days. Schloesing, Müntz, Pasteur, Munro, Percy Frankland, and others, have shown that one of the most important of plant-foods in the soil is nitric acid, and that this substance is elaborated from ammonia by the action of minute living organisms. The singular fact has been demonstrated that the work is performed by a system of division of labour, one kind of bacterium converting the ammonia into nitrous acid and declining to do any more, when another species takes up the work and produces nitric acid, which presents the nitrogen in a form which can be assimilated by the plant. "Not only," to use the words of Dr. P. Frankland, "is this process of nitrification going on in the fertile soils, but enormous accumulations of the products of the activity of these minute organisms in the shape of nitrate of soda are found in the rainless districts of Chili and Peru, from whence the Chili saltpetre, as it is called, is exported in vast quantities, more especially to fertilise the overtaxed soils of Europe!" But more than that, long and patient research has established the fact that, in certain of the legumenous plants, the same microscopic agency acting in the roots endows them with the power of assimilating the nitrogen of the atmosphere, and by that means makes them the instruments for actually enriching the soil instead of exhausting it.

I have already alluded to the circumstance that the engineer cannot be satisfied with vague statements or with mere abstract opinions. The very nature of his calling implies action; he has to construct, his works must be stable, his machinery must act, his estimates of cost and of the consequences of his operations must come true, and hence he has to make a close alliance with that most fascinating and fruitful of the sciences—mathematics. It is not given to many to possess the peculiar aptitude which leads up to the highest investigation, but neither has the engineer often need of anything deeper than almost elementary knowledge, especially if he gets into the habit of working out the problems that come before him by the graphic methods which are now so assiduously cultivated, and if he will realise that slovenliness in the matter of calculations commonly leads to disastrous results. Though his attainments may not be high, and though disuse may have made it difficult to wield the power which knowledge, early acquired, once gave him, yet he can always appreciate and put his faith in the great minds which delight in subjecting the theories of physicists to the rigid test of mathematical analysis, and thereby stamping them with the seal of irrefragable fact.

One great quality he must possess, especially in these days when numerous science colleges have rendered high mathematical training of easy access—and that is common sense. There is a tendency among the young and inexperienced to put blind faith in formulæ, forgetting that most of them are based upon premises which are not accurately reproduced in practice, and which, in any case, are frequently unable to take into account collateral disturbances, which only observation and experience can foresee, and common sense provide against.

I have endeavoured to show how the history of abstract science, by which I intend to designate the history of researches entered into for the sole purpose of acquiring knowledge of the operations of Nature and of her laws, without any thought of reward, or expectation of pecuniary advantage, has had its reflex in the records of the engineering profession, and how the most recondite investigations, apparently unlikely to have any direct influence on our practice, have, in course of time, become of cardinal importance. I have also ventured to point out how, in these days, the engineer must banish from his mind the idea that anything can be too small or too trifling to deserve his attention. "Nothing is too small for the great man," is, I am told, written over the cottage once occupied by Peter the Great at Saardam. The truth embodied in that legend should ever dwell in our minds; for success, I am persuaded, lies largely in close attention to details.

The discourse concluded by a warm tribute to the merits of the old servant of the Institute who had established the lectureship.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—It is proposed to appoint a Syndicate for the purpose of considering the desirability of establishing an examination in agricultural science, open to all trained students, whether members of the University or not. The successful candidates in such an examination would receive a University diploma similar to the existing diploma in Public Health. It is understood that this plan has received the approval of the Royal Agricultural Society and the Board of Agriculture. These bodies, and certain of the County Councils, have further agreed to subsidise a scheme for the regular instruction within the University of candidates for the examination if it be established.

SCIENTIFIC SERIALS.

American Journal of Science, May.—Deportment of charcoal with the halogens, nitrogen, sulphur, and oxygen, by W. G. Mixter. The tenacity with which charcoal retains hydrogen even after ignition in chlorine makes it difficult to decide whether certain gases absorbed by charcoal are occluded or chemically combined with it. Experiments performed on sugar-charcoal, gas carbon, and "Diamond Black," a variety of lampblack derived from natural gas, indicate that chlorine does combine with charcoal, but that the combination is brought about by a replacement of the hydrogen. Pure native diamond and graphite do not take up chlorine, while iodine and bromine are not absorbed even by impure charcoal. Nearly pure amorphous carbon takes up but little sulphur, while a soft charcoal containing much hydrogen and oxygen combines with a considerable amount, taking it up even from carbon bisulphide.—Note on some volcanic rocks from Gough's Island, South Atlantic, by L. V. Pirsson. An examination of beach pebbles from the shores of this craggy island, 240 miles S.E. of Tristan da Cunha, establishes its recent volcanic nature, and thus adds one more to the line of mid-Atlantic volcanoes which, sweeping southward through the Azores, Cape Verde Islands, Ascension, St. Helena, and Gough's Island, terminates on Bouvet Island on the confines of the Antarctic Ocean.—The influence of free nitric acid and aqua regia on the precipitation of barium as sulphate, by Philipp E. Browning. In the presence of nitric acid to the extent of 5 per cent. very little solvent action is shown, and the sulphate may be safely filtered after an hour's time. Even with 20 to 25 per cent. the solubility does not exceed 0·001 grm. on the average. Aqua regia has even less solvent effect, and the presence of ten per cent. of either is a positive advantage since it gives the precipitated sulphate a coarsely crystalline form.—On a rose-coloured lime-and-alumina bearing variety of talc, by Wm. H. Hobbs. A talcose mineral was found developed in some specimens of white crystalline dolomite from Canaan, Conn., on lines evidently corresponding to fracture planes in the rock. One of the specimens had a deep rose colour, the other was nearly white, having lost its colour by exposure to light. The mineral was shown to belong to the talc family by its chemical composition and its physical properties, but it differed from known varieties by its colour, its high percentages of lime and alumina, its low fusibility, and by its being easily decomposed by acids.—Also papers by Messrs. A. M. Edwards, A. W. Whitney, S.-T. Moreland, S. L. Penfield, N. H. Darton, and M. I. Pupin.

Bulletin of the New York Mathematical Society, vol. ii. No. 7 (New York, April 1893).—The contents are a review, by J. Harkness, of Prof. Greenhill's "The Applications of Elliptic Functions" (pp. 151-57), in which, though there is much appreciative commendation, there is also the *amari aliquid* to add pungency to the criticism.—Next comes a further contribution, the third, on the non-Euclidian Geometry (pp. 158-61), this time by Prof. W. Woolsey Johnson.—The remaining articles are a notice of the Lehrbuch der Ausgleichsrechnung nach der Methode der Kleinsten Quadrate of Dr. Bobek, and the theory of errors and method of least squares of W. Woolsey Johnson, by Mansfield Merriman (pp. 162-63); and two notes (1) on the definition of logarithms (*i.e.* the definition given by Prof. Stringham in the *Amer. Journ. of Math.*, vol. xiv.), by Prof. Haskell; (2) a note on the preceding note, by Prof. Stringham (pp. 164-70).—The number closes with general notes and list of new publications.

SOCIETIES AND ACADEMIES.

London.

Royal Society, March 9.—"The Electrolysis of Steam." By J. J. Thomson, M.A., F.R.S., Cavendish Professor of Experimental Physics in the University of Cambridge.

The following explanation of the results of the experiments seems to the author to be that which agrees best with preceding investigations.

When an electric discharge passes through a gas the properties of the gas in the neighbourhood of the line of discharge are modified. Thus, as Hittorf and Schuster have shown, the gas in the neighbourhood of the discharge is no longer an insulator, but can transmit a current under a very small potential difference. Faraday's remark, that when once a spark has passed through a gas the passage of another following it immediately afterwards is very much facilitated, is another example of the same thing. We have thus good reasons for believing that when a spark passes through a gas it produces a supply of a modification of the gas, whose conductivity is enormously greater than that of the original gas. I have shown ('Phil. Mag.,' November 1891) that the conductivity of this modified gas is comparable with that of strong solutions of electrolytes. When the discharge stops, this modified gas goes back to its original condition. If now the discharges through the gas follow each other so rapidly that the modified gas produced by one discharge has not time to turn to its original condition before the next discharge passes, the successive discharges will pass through this modified gas. If, on the other hand, the gas has time to revert to its original condition before the next discharge passes, then the discharges pass through the unmodified gas; we regard this as being accomplished by means of successive decompositions and recombinations of its molecules, analogous to those which, on Grotthus' theory of electrolysis, occur when a current passes through an electrolyte.

We regard the arc discharge as corresponding to the first of the preceding cases where the discharge passes through the modified gas, the spark discharge corresponding to the second when the discharge goes through the gas in its unmodified condition.

From this point of view, the explanation of the results of the experiments on the electrolysis of steam are very simple. The modified gas produced by the passage of the discharge through the steam consists of a mixture of hydrogen and oxygen, these gases being in the same condition as when the arc discharge passes through hydrogen and oxygen respectively, when, as we have seen, the hydrogen behaves as if it had a negative charge, the oxygen as if it had a positive one. Thus, in the case of the arc in steam, the oxygen, since it behaves as if it had a positive charge, will go to the negative, while the hydrogen, behaving as if it had a negative charge, will go to the positive electrode. We saw that this separation of the hydrogen and oxygen took place.

The correspondence between the quantities of hydrogen and oxygen from the electrolysis of the steam and those liberated by the electrolysis of water shows that the charges on the atoms of the modified oxygen and hydrogen are the same in amount, but the opposite in sign to those we ascribe to them in ordinary electrolytes.

In the case of the long sparks where the discharge goes through the steam, since the molecule of steam consists of two positively charged hydrogen atoms and one negatively charged oxygen one, when the molecule splits up in the electric field the hydrogen will go towards the negative, the oxygen towards the positive, electrode, as in ordinary electrolysis.

April 27.—"On the Coloration of the Skins of Fishes, especially of Pleuronectidæ." By J. T. Cunningham, M.A. Oxon., Naturalist on the Staff of the Marine Biological Association, and Charles A. MacMunn, M.A., M.D. Communicated by Prof. E. Ray Lankester, F.R.S.

The anatomical analysis of the structural coloration elements having not previously been adequately carried out, we have described these elements as they are found in the Pleuronectidæ and various other fishes. In the former family there are two kinds of chromatophores, the black and the coloured, the latter usually of some shade of yellow or orange. The coloured elements in the skin on the upper side are chiefly developed in the more superficial layer immediately beneath the epidermis and for the most part outside the scales, and on the inner side of the skin in the subcutaneous tissue, the rest of the skin being almost destitute of these elements. In the superficial layer the iridocytes are somewhat polygonal plates of irregular shape, distributed uniformly, and separated by small interspaces. The chromatophores are much larger, and farther apart, and are superficial to the iridocytes, although sections show that their processes often pass down between adjacent iridocytes. The coloured chromatophores have less definite outlines than the black, and as a rule radiating processes are but indistinctly indicated in them. The external part of the coloured chromatophore consists of diffused yellow pigment, while in the centre the concentration of the pigment produces a deeper colour, varying from orange to red, as in the plaice and flounder. On the upper side of the fish the subcutaneous coloration elements are quite similar, but not so uniformly distributed; the iridocytes are larger, and the chromatophores not so symmetrical in shape.

The lower side of the normal flounder is uniformly opaque white, like chalk. Here in the more superficial part of the skin there is a uniform layer of iridocytes like those of the upper side, opaque and reflecting, but not very silvery or iridescent. Chromatophores are entirely absent. In the subcutaneous layer there is a continuous deposit of reflecting tissue, to which the whiteness of the skin is due, the superficial iridocytes not being sufficiently thick to make the skin so opaque.

We have shown by descriptions of the coloration elements in a number of species of symmetrical fishes such as mackerel, whiting, gurnard, *Cottus*, pipe-fishes, &c., that the general distribution of the elements is constant in all, the differences being in minute details.

In chemical and physical properties the substances contained in the coloration elements are as distinct as the elements are in appearance and form. The black chromatophores owe their colour to a melanin which is granular in its natural condition, is a nitrogenous body, and is very refractory towards reagents. The pigment of the coloured chromatophores is always a lipochrome, and the absorption bands of the various lipochromes obtained from the fishes examined do not differ to any great degree. The reflecting tissue was found always to consist of guanin in the pure state, not, as has often been stated, to a combination of guanin and calcium.

These investigations of the elements and substances of coloration were undertaken in order to find out what exactly took place when coloration was developed on the lower side of flounders in certain experiments carried on at the Plymouth Laboratory since the spring of 1890. The first experiment was not quite conclusive, although some pigment was found on the lower sides of the fish after an exposure to light of four months. The second experiment was quite conclusive. Four flounders were taken on September 17, 1890, from a number reared in the aquarium since the preceding May: they were five to six months old, and 5 to 8 cm. in length. They had been living under ordinary conditions, and were in all respects normal, having no colour on the lower sides. They were placed in the vessel above the mirror. On one of these, two faint specks of pigment were observed on April 26, 1891, one died on the following July 1, which showed no pigment, and one on September 26, 1891. The latter was 16·7 cm. long and showed only a little pigment on the posterior part of the operculum. At this time one of the two survivors had developed pigment all over the external regions of the lower side, and the other had a few small spots. The first of these two is still alive (March, 1893), being now three years old, and it is now pigmented over the whole of the lower side except small areas on the head and the base of the tail. A drawing showing its condition in November, 1891, was exhibited at the *soirée* of the Royal Society in 1892, and is laid before the Society with this paper. The other specimen died on July 4, 1892. It was then 25 cm. long and had a good deal of pigment in scattered spots on the lower side. This specimen had been exposed about one year and ten months. Several other experiments gave similar results.

The occurrence of abnormal coloration in pleuronectids is fully considered in the memoir; a large number of specimens are described, and it is shown that there is no evidence whatever that these specimens have been exposed to abnormal conditions. We conclude that these abnormalities are congenital and not acquired.

We conclude that exposure to light does actually cause the development of pigment in the form of normal chromatophores on the lower side of the flounder, and also causes the absorption of the argenteum to a great extent. We infer, in spite of the occurence of congenital abnormalities, that the exclusion of the light from the lower sides of flat fishes is the cause of the absence of pigment from that side in normal specimens. We think that the fact that the metamorphosis of the flounder takes place at first normally, in spite of the light coming from below and being shut off from above, is, in respect of the pigmentation, in favour of the inheritance of acquired characters. When the exposure is continued long enough, the change that has taken place in consequence of heredity is reversed, and pigment appears.

We consider that these investigations afford support to the view that the incidence of light is the reason why the upper and dorsal surface of animals is more strongly pigmented than the lower or ventral throughout the animal kingdom, and that the absence of light is the cause of the disappearance of pigment in many cave-inhabiting and subterranean animals.

Zoological Society, May 2.—Sir W. H. Flower, F.R.S., President, in the Chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of April; and called special attention to a young male Orang (*Simia satyrus*) brought home from Singapore, and presented by Thomas Workman, Esq.; a White-bellied Hedgehog (*Erinaceus albiventer*) from Somaliland, presented by H. W. Seton-Kerr; and a female Gibbon (*Hylobates muelleri*) brought home from North Borneo, and presented by Leicester P. Beaufort.—The Secretary laid on the table a list of the exact dates of the issue of the sheets of the Society's "Proceedings" from 1831 to 1859, concerning which information had lately been applied for.—Mr. P. L. Sclater, F.R.S., made some remarks on the occasional protrusion of the cloaca in the Vasa Parrot at certain seasons.—Mr. Sclater also read some further notes on the Monkeys of the genus *Cercopithecus*, and called special attention to *C. boutourlinii*, Giglioli, from Kaffa, Abyssinia, of which he had lately examined specimens in the Zoological Museum of Florence, and which he considered to be a perfectly valid species.—Mr. M. F. Woodward read a paper (the first of a series) entitled "Contributions to the Study of Mammalian Dentition." In the present communication the author treated of the dentition of the Macropodidæ, and described the presence of a number of vestigial incisors. He also showed that the tooth generally regarded as the successor to the fourth premolar was, in reality, a distinct tooth, and that the molars in this family of Marsupials belonged to the second dentition.—Mr. W. T. Blanford, F.R.S., read a description of two specimens of a Stag from Central Tibet, belonging to the Elaphine group, on which he proposed to found a new species, *Cervus thoroldi*. These specimens had been obtained by Dr. W. G. Thorold about 200 miles north-east of Lhasa, at an elevation of 13,500 feet above the sea-level, during his late adventurous journey through Tibet in company with Capt. Bauer.

Royal Microscopical Society, April 19.—A. D. Michael, President, in the Chair.—Mr. E. M. Nelson exhibited and described a mirror to be used instead of the camera lucida for the purpose of reflecting the real image from the microscope for drawing.—Mr. C. Rousselet exhibited a compressorium, the great advantage of which was that it enabled the object to be seen in every part of the field.—Mr. R. Macer exhibited and described a reversible compressorium which he thought might be useful.—Dr. G. P. Bate read a note on the illumination of diatoms by light reflected from the cover-glass in such a way as to produce a white ground illumination.—A letter from Captain Montgomery, describing the abundance of ticks in the coast lands of Natal, was read by Prof. Bell.—Mr. H. M. Bernard gave a *résumé* of his paper on the digestive processes in Arachnids.—Prof. Bell said that Mr. Bernard had made it appear probable that digestion was not confined to the digestive tract as usually understood, and in that case it might be that they were at the beginning of a series of observations which might throw a new light upon the processes of digestion.—The President said he had never worked much on these groups except amongst the Acarina. It was a curious thing that the distribution of the crystals referred to by Mr. Bernard was by no means the same in different families of the Acarina; in the majority of cases they lie outside the canal altogether, and are not found inside until they reach the hind gut. In the Gamasidæ they are poured into the cloaca. On the other hand there are families, such as the Tyroglyphidæ, where the crystals apparently never enter the hind gut at all, but are spread through the general body cavity. In the Oribatidæ a medium course seems to hold good, it being very difficult to ascertain where they enter the hind gut. Whilst in the Trombididæ they seem to enter in a definite channel down the centre of the back.—Mr. F. Chapman read a fourth paper on the Foraminifera of the Gault of Folkestone.—Prof. D'Arcy Thompson's paper on a Tænia from an Echidna was read by Prof. Bell.—Mr. C. H. Gill called attention to some pure cultivations of Diatoms which he exhibited.

EDINBURGH.

Royal Society, May 1.—Sir Douglas Maclagan, President, in the Chair.—A paper by Mr. John Aitken, on breath figures, was read. These figures are generally produced by breathing upon a piece of glass, on opposite sides of which two coins, or a coin and a piece of metal, have been placed, and have been oppositely electrified to high potentials. An image of the coin is thus developed. It appeared to the author that these figures depended on the presence of dust, or other impurities on the surface of the glass, and that similar effects might be produced by means of heat. The results of his experiments verified his conjecture and showed that dust has an effect on the formation of some kinds of breath figures.—A paper, communicated by Mr. H. B. Stocks, on some concretions from coal measures, and the fossil plants which they contain, was read. The concretions are found at Halifax, Yorkshire, and at Oldham, Lancashire. They are called "coal-balls" by the miners, and are found in a bed, belonging to the lower coal measures, above a stratum containing marine shells. The chief constituents are carbonate of lime and iron pyrites. The remains of plants which the balls contain are wonderfully preserved, every cell being well defined. Often the nodule is a mass of fosil wood, with a thin mineral coating. The author thinks that the bed has been formed in shallow water near the sea coast, the process of formation being similar to that now going on in the mangrove swamps of South America.—Lord Maclaren communicated a paper on the general eliminant of three equations of different degrees.

PARIS.

Academy of Sciences, May 8.—M. Lœwy in the chair.—On the equation $\Delta u = ke^u$, by M. Émile Picard.—On an objection to the Kinetic theory of gases, by M. H. Poincaré. If, in equation 75 of the theory of adiabatic expansion, Maxwell had made $Q = \phi$ instead of $= \theta$, as he ought to have done, since Q is a function of $u+\xi$, $v+\eta$, $w+\zeta$, he would have obtained the formula

$$\frac{dp}{p} = \frac{5}{3}\frac{d\rho}{\rho}$$

where p is the pressure and ρ the density. This formula is not in accordance with experiment, but is a legitimate conclusion from the kinetic theory. Another error is pointed out in the theory of the conductivity of gases, where Maxwell's formula $K = \frac{5}{3\gamma}\nu$ ought to have been $K = \frac{5}{2\gamma}\nu$. For air, the experimental value is 56×10^{-6}, the calculated value from Maxwell's formula 54×10^{-6}, and the value calculated from the corrected formula 81×10^{-6}.—Shooting stars and fluctuations of latitude, by M. d'Abbadie.—On a new type of phosphorites, by M. Armand Gautier.—On a general case in which the problem of the rotation of a solid body admits of integrals expressible by means of uniform functions, by M. Hugo Gyldén.—The surmulot in the ancient western world, by M. A. Pomel. From evidence furnished by archæological excavations carried out by Prof. Waille at Cherchell, on the coast of Algiers, it appears that the surmulot or Norway rat, *Mus decumanus*, lived there at the time of the Roman occupation, instead of invading Europe from India in the middle of the eighteenth century. There appears to be no doubt that the remains found were contemporary with the Roman settlement of Julia Cæsarea.—Mr. Rowland was elected correspondent for the section of physics in the place of the late M. Soret.—Researches on the formation of the planets and satellites, by M. E. Rodger.—Solar observations of the first quarter of 1893, by M. Tacchini.—On isothermal surfaces with plane lines of curvature in one or both systems, by M. P. Adam.—On the transcendentality of the number e, by M. Gordan.—On an application of the theory of Lie's groups, by M. Drach.—On the limitation of degree for algebraic integrals of the differential equation of the first order, by M. Autonne.—On a theorem relating to the transformation of algebraic curves, by M. Simart.—On a class of dynamical problems, by M. Goursat.—Remarks on the specific heat of carbon, by M. H. Le Chatelier. Recent experiments conducted by MM. Euchène and Biju-Duval, engineers to the Parisian Gas Company, place beyond doubt the conclusion arrived at by M. Monckman, that the specific heat of carbon does not asymptotically approach a certain value as the temperature rises. A large number of experiments show that the specific heat of graphite increases between 250° and 1000° in a manner rigorously proportional to the temperature. For temperatures between 0° and 250° the atomic heat $c = 1.92 + 0.0077t$, and between 250° and 1000° $c = 3.54 + 0.00246t$.—Electric interferences produced in a liquid lamina, by M. R. Colson.—On the flame-spectra of some metals, by M. Denys Cochin.—An attempt at a general method of chemical synthesis, by M. Raoul Pictet.—On the basicity and the functions of manganous acid, by M. G. Rousseau.—On the constitution of licareol, by M. Ph. Barbier.—On aluminium chloride syntheses, by M. P. Genvresse.—On a liquid isomer of hydrocamphene, by M. L. Bouveault.—On the chemical composition of essence of Niaouli, by M. G. Bertrand.—Methodical moulding of glass, by M. Léon Appert.—On basic nepheline rocks of the Central Plateau of France, by M. A. Lacroix.—On the quantities of water contained in the arable lands after a prolonged drought, by MM. Demoussy and Dumont. The percentages of water contained in garden earth at depths of 0, 25, 50, 75, and 100cm. respectively were 4·5, 27·1, 24·0, 24·2, and 22·8. One hectare of such soil, 1m. deep, and weighing 12000 tons, would therefore contain 2460 tons of water, while a specimen of open land containing double the amount of fine sand contained only 1400 tons of water.—Comparative toxicity of the blood and the venom of the common toad (*Bufo vulgaris*), considered from the point of view of the internal secretion of the cutaneous glands of this animal, by MM. Phisalix and G. Bertrand.—The pyocyanic bacillus among vegetables, by M. A. Charrin.—Microbian synthesis of tartar and salivary calculus, by M. V. Galippe.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Essays on Rural Hygiene: Dr. G. V. Poore (Longmans).—Notes on Recent Researches in Electricity and Magnetism: Prof. J. J. Thomson (Oxford, Clarendon Press).—The Health Resorts of Europe: Dr. T. Linn (Kimpton).—Catalogue of the Snakes in the British Museum (Natural History), vol. 1: G. A. Boulenger (London).—Lehrbuch der Botanik, Zweiter Band: Dr. A. B. Frank (Leipzig, Engelmann).—Sitzungsberichte der K. b. Gesellschaft der Wissenschaften. Math.-Naturw. Classe 1892 (Prag).—The Story of the Atlantic Telegraph: H. M. Field (Gay and Bird).—The Mammals of Minnesota: C. L. Herrick (Minneapolis, Harrison).—U.S. Commission of Fish and Fisheries; Commissioner's Report, 1888 (Washington).—Geology of the Eureka District, Nevada, and Atlas to ditto; A. Hague (Washington).

PAMPHLETS.—The Moon's Face: G. K. Gilbert (Washington).—Observations on Karyokinesis in Spirogyra; Dr. J. W. Moll (Amsterdam, Müller).—The Colours of Cloudy Condensation: Prof. C. Barus.—Beiträge zur Anatomie holziger und succulenter Compositen: J. Müller (Berlin, Friedländer).—Report on the Climatology of the Cotton Plant: Dr. P. H. Mell (Washington).

SERIALS.—Journal of the Institution of Electrical Engineers, No. 105, vol. xxii. (Spon).—The Physical Society of London Proceedings, vol. xii. Part 1 (London).—Proceedings of the Academy of Natural Sciences of Philadelphia, 1892, Part 3 (Philadelphia).—Zeitschrift für Wissenschaftliche Zoologie, 56 Band, 1 Heft (Williams and Norgate).—Morphologisches Jahrbuch, 20 Band, 1 Heft (Williams and Norgate).—Mémoires de la Section Caucasienne de la Société Impériale Russe de Géographie, livre xv.

CONTENTS.