THURSDAY, JULY 7, 1892.

A SYSTEM OF MINERALOGY.

The System of Mineralogy of James Dwight Dana, 1837–68: *Descriptive Mineralogy*. Sixth Edition. By Edward Salisbury Dana, Professor of Physics, and Curator of the Mineral Collection, Yale University. Entirely rewritten and much enlarged. Pp. lxiii. and 1134. Illustrated with over 1400 Figures. (New York and London: Kegan Paul, Trench, Trübner, and Co., 1892.)

IN the whole history of scientific literature it would be difficult to find a parallel to Dana's "System of Mineralogy," for there is probably no work which, like it, has maintained for more than half a century its position as the best and most complete work of reference on a branch of natural history. In spite of the enormous additions to our knowledge of the chemical and physical properties of well-known minerals, and of the discovery of innumerable new species and varieties, during that long period, the work has been carefully kept up to date; and so thorough and judicious have been the revisions to which successive editions have been subjected, that the book may at the present time fearlessly challenge comparison with the latest and most successful attempts to supply a comprehensive survey of mineralogical science.

When the work first appeared, in 1837, its author made a determined attempt to grapple with the difficult problem of mineralogical nomenclature and classification; like many of his contemporaries, he was sanguine of being able to make the taxonomy of mineralogy correspond with that of the other natural-history sciences, and a so-called *natural* system of classification, based on that of Mohs, was adopted by him. But on the appearance of the third edition in 1850 the futility of all such attempts was admitted, and a scheme of classification founded upon chemical composition was substituted; it is this system of classification which, with some modifications rendered necessary by the progress of discovery, is employed in the present edition.

On reaching its fourth edition in 1854, the work had grown to such an extent that it became necessary to divide it into two volumes: the first devoted to a general introduction to crystallography, with mineral physics and chemistry, and the second to descriptive mineralogy. The necessity for the re-issue of the first of these volumes has been obviated, however, by the publication in 1875 of the "Determinative Mineralogy" by the author's friend and fellow-worker, Prof. Brush, and by the appearance, two years later, of the "Text-book of Mineralogy," in the preparation of which the author had the able co-operation of his son, Prof. Edward Salisbury Dana. In this way the "System of Mineralogy" has now been limited to the descriptive portion of the original work, and only a few pages of introductory matter are given to explain the terminology, symbols, and abbreviations which it has been found necessary to employ. A noteworthy change in the fifth edition, and one which has tended to greatly increase the value of the work for reference purposes, was the fuller recognition and description of varieties, and of the localities from which they have been obtained; the very thorough revision of the historical synonymy, which was undertaken for this fifth edition, also greatly enhanced the usefulness of the book. These historical details and references, which have entailed a vast amount of bibliographical research, have been retained with but few modifications in the present edition.

In the preface to this fifth edition, Prof. Dana wrote in 1868 as follows:—

"In these and other ways the volume has unavoidably become enlarged. Not a page, and scarcely a paragraph, of the preceding edition remains unaltered, and fully five-sixths of the volume have been printed from manuscript copy. I may here add that, notwithstanding the impaired state of my health, this manuscript—the paragraphs on the pyrognostic characters excepted—was almost solely in the handwriting of the author, or in that of a copyist from it. Neither the consultation of authorities, the drawing of conclusions, nor the putting of the results on paper, has been delegated to another. And being now but half-way between the fifties and sixties, it is my hope that the future will afford another opportunity for similar work."

In writing these lines, Prof. Dana could scarcely have foreseen that the issue of the sixth edition of the work would be delayed for 24 years. During that period three appendices have been prepared by the author, and he has shown, in numerous books and original memoirs on various branches of geology and natural history, an unabated interest and zeal in scientific work. But the very heavy task of incorporating the matter of the appendices into a new edition, and of revising and re-arranging the whole work, has had to be delegated by the author to his son, and certainly it could not have been placed in more competent hands. Every mineralogist will rejoice that the familiar and excellent features of the original work have been carefully preserved. The book, indeed, is so well known to all working geologists and mineralogists, that we cannot do better than to indicate the chief changes which have been found necessary in the present edition, in order to bring it up to date and maintain its high character.

The work now contains more than one-half more matter than the fifth edition, and, to keep it down even to this limit, a very rigid system of abbreviation and condensation has had to be adopted, while the size of the page has been increased by one-fifth. The historical account of the species remains substantially the same as in the last edition, but names commonly employed in important languages, in addition to English, French, and German, have been given.

In the chemical portion of the work very considerable changes have been introduced. The difficult question of the classification of the silicates has received the fullest consideration, and the views of Rammelsberg, Tschermak, and other chemists on each species are clearly indicated. It has no longer been found possible, however, to give a statement of all the analyses that have been made of a species. The microscopic work of Lacroix and others has shown that many of these analyses are worthless, as the material operated upon has been a mixture and not a homogeneous substance. In the present edition all trustworthy analyses of rare minerals have been given, and in the case of common minerals, where the number of published analyses is very great, a judicious selection of the best and most recent analyses has been made.

The statement of the optical constants and the physical characters of minerals has been treated in much the same fashion as the chemical data. The best and most trustworthy determinations have been selected, while measurements of doubtful value have been omitted.

It is on the crystallographic portion of the work, however, that Prof. E. S. Dana has expended the greatest amount of labour. We are informed in the preface that "an attempt has been made to trace back to the original observer the fundamental angles for each species, then the axes have been recalculated from them, and finally the important angles of all common forms have been calculated from these axes." The author is able to state that in every case this recalculation of the angles of all the forms of a mineral has been undertaken, and that no pains has been spared in the verification and correction of the results. The crystal forms are indicated by letters, and the symbols employed are in the first instance those of Miller, and in the second instance the modified form of Naumann's symbols familiar to all who have used the earlier editions of the work. The author gives it as his opinion that the former should eventually supplant the latter altogether. In the hexagonal and rhombohedral system, however, the Bravais-Miller system is adopted in preference to that of Miller.

With few exceptions, the figures of crystals (1400 in number) are new. Many have been drawn from original data, and those taken from other works have been redrawn so as to secure uniformity of projection; the habits of each species and the types of twinning in crystals have been very fully illustrated.

While the general account of the mode of occurrence and association of mineral species has been very carefully attended to, there has been no attempt to make this part of the work exhaustive, for to have done so would have greatly increased the bulk of the volume. The account of American localities—which has always been an important feature of Dana's work, and has made it for North America what the treatises of Kokscharov and Zepharovitch are for the Russian and Austrian Empires respectively—has been greatly added to. The works of Roth and Hintze, with the numerous books and memoirs devoted to the geology of particular regions, now supply all the information that is needed in respect to mineralogical distribution in other areas.

We have tested the volume in many ways as to the completeness and recent nature of the information given with respect to particular species, and always with satisfactory results. To pass such a voluminous mass of information through the press has required eighteen months of labour, and notices of important contributions to our knowledge that have appeared since the earlier pages of the book were printed off have been relegated to a supplement. This supplement, which extends to 28 pages, also contains brief accounts of minerals of unknown composition, and of doubtful species having little or no claim to recognition.

In conclusion, we must congratulate both the original author of the "System," and the writer of the volume in its present form, on the completion of their useful labours. It is not too much to say that the publication of each successive edition of this work has constituted an epoch in the history of mineralogical science; and the present edition, coming from the hands of a new author, completely maintains the prestige of former ones.

J. W. J.

MODERN INFINITESIMAL CALCULUS.

An Introduction to the Study of the Elements of the Differential and Integral Calculus. From the German of the late Axel Harnack, Professor of Mathematics at the Polytechnicum, Dresden. (London and Edinburgh: Williams and Norgate, 1891.)

MR. G. L. CATHCART'S translation forms a handsome volume, and will prove acceptable to those engaged in mathematical teaching, as a storehouse of suggestive methods and ideas for analytical exegesis.

But let us examine the work from the standpoint of the student approaching the subject of the Calculus for the first time, supposing this book to be put into his hands to acquire his first acquaintance with the method and reasoning.

Until very recently the Classics, Greek and Latin, as taught at school, were looked upon chiefly as collections of grammatical examples, and the subject-matter was lost sight of in the careful parsing and analysis of the sentences. Boys were taught on a system which implied that they were all, in their turn, to become schoolmasters and instructors; and the interests of the majority, who would profit intellectually from the literary study of the ancient masterpieces, were completely neglected.

So, too, in Mathematics: the ordinary text-books give an excellent schoolmaster's training in the subject; but the large and increasing class of students, brought into existence recently by the commercial developments of scientific application, who are required to put into immediate practice the theory which they find indispensable, cannot afford the time to be dragged the whole length of the quagmire of the Convergency of Series, of Inequalities, of Discontinuity, and of the so-called Failure of Taylor's Theorem. These are the quagmires in which the mere mathematician delights to lose himself, and also to lure in others after him.

To one who is already very familiar with the notation and operations of the Calculus the present treatise will prove, not repellent, but even fascinating to minds who pursue the subject for its purely analytical interest. Having been over the road before, they will be prepared to appreciate the strictly logical order in which the theorems are developed, starting in Chapter I. with the fundamental conceptions of Rational Numbers, of their Addition, Subtraction, Multiplication, and Division—the subject of Arithmetic in short; and passing on in Chapter II. to Radicals and Irrational Numbers in general. The next three chapters treat of the Conceptions of Variable Quantities, of Functions of a Variable, their Geometric Representation and Continuity; and it is not till the sixth chapter that the Differential Coefficient is introduced and determined for the simplest functions.

But the beginner, who has had the courage to read thus far, will wonder what on earth the subject is all about, even when he has reached the end of Book I., which covers the ground of the subject usually called the Differential Calculus: there are no illustrations, except for one or two meagre geometrical applications, for the mind to hold on by; no diagrams, and no examples to test the soundness of the student's knowledge.

It is true that these collections of examples are decried in certain lofty quarters of the mathematical hierarchy; but the humbler priests of the science, who are in touch with the noviciate mind of human nature, know their practical value; and these collections of problems, formerly a feature of our text-books unknown abroad, are now being extensively copied and adopted in other countries. "In scientiis ediscendis prosunt exempla magis quam præcepta" (Newton).

The Second Book considers Functions of Complex Numbers: we make another fresh start with the operations of Arithmetic, as it is called here; not that any resemblance can be traced to what generally goes by that name. In this book the questions of Convergency, of Single- and Multiple-valued Functions, as illustrated by a Riemann surface, and of their Zeros and Infinities, are gone into at great length; but at the same time the reader will have an impression that the information is given in a very condensed form, and that an attempt has been made to give a brief *résumé* of a subject which requires a large volume to itself.

This Morbid Pathology of the Mathematical Function, as we may call it, requires a very clear, concise, and cosmopolitan tereminology, which, as Mr. Cathcart points out on p. 148, it does not yet possess; it is unfortunate that the nomenclature has mostly been formed originally in the agglutinate German language, and in many cases is only very imperfectly translatable.

This part of the subject, although principally known to us from the researches of later writers, such as Cauchy, Riemann, Dirichlet, and Weierstrass, owes very much to Gauss; but Gauss deserves to lose the credit of priority, from his baneful habit of bottling up his discoveries, after announcing that he had obtained the solution, so as to warn off all other investigators from his preserves of research.

The Integral Calculus is developed in Book III.; here also the treatment, though complete, is very condensed; and but few simple problems and applications are provided to show the use of the subject when the analysis is established.

The author never employs the hyperbolic functions, although their use can be traced back to Newton ("Principia," Lib. II., Prop. ix.); but in the reductions of the integral of $F(x, \sqrt{R})$ where R is the quadratic $a + 2bx + cx^2$, the use of $\sqrt{R}$ as the argument in conjunction with the circular and hyperbolic functions enables us to present the different results which arise in a more systematic manner than that employed in the present work. A very short sketch is also given of the method of reduction of the integrals when R is of the third or fourth degree; the elliptic integrals are now introduced, but no mention is made of the elliptic *functions*, introduced by Abel by the inversion of the elliptic *integrals*.

The Fourth Book, which treats of the integrals of complex functions and of the general properties of analytic functions, is probably the sole presentation of this modern and difficult subject in our language. To a mathematician of Mr. Cathcart's development the treatment will appear very concise and elegant, but for our part we miss the footholds afforded by the physical applications of the general theorems of functions; say to Hydrodynamics, such as those recently published by Prof. W. Burnside in the Proceedings of the London Mathematical Society, on Riemann's Theory and on Automorphic Functions, determined from their discontinuities.

The book will recommend itself, as we said at the outset, to the advanced student, who pursues mathematical study as an end to itself, by reason of the strict logical order in which the subjects are presented; but is this strict logical order the most suitable arrangement for a beginner?

Herbert Spencer says that "in each branch of instruction we should proceed from the empirical to the rational." In the operatic version of "Manon" the events are presented in chronological order; but in the original "Histoire de Manon Lescaut" the story begins in the middle, so as to excite the reader's curiosity as to the preceding events which led up to the point at which the characters appear on the scene.

According to Prof. Harnack's preface, the present work may be considered the operatic version of his lectures, while the simple story would appear in the lectures delivered in the Dresden Polytechnicum to his technical students, who required a knowledge of Analysis chiefly as an instrument for the solution of mechanical problems.

Mr. Cathcart explains in his Translator's Note the desire he had to make these lectures accessible to the English reader, and records the regret he felt at the news of the death of Prof. Harnack, while engaged on a revision of his notes for a new edition. The thanks of the mathematical world are due to Mr. Cathcart for the care and trouble he has taken in this valuable piece of work.

A. G. GREENHILL.

ALTERATIONS OF PERSONALITY.

Les Altérations de la Personnalité. Par Alfred Binet. Bibliothèque Scientifique Internationale. (Paris: Ancienne Librairie Germer Baillière et Cie., 1892.)

IN what is in ordinary parlance called somnambulism, or sleep-walking, the patient rises in the night, performs a number of seemingly intelligent actions directed to some special end, answers questions with regard to such actions with a variable amount of coherence, returns to bed, and generally, but not in all cases, wakes in the morning with no remembrance of that which he has done during the night. Such is somnambulism in its narrower sense. It exhibits the individual in an abnormal psychological condition, the actions performed in this abnormal condition being generally unconnected in memory with the normal sequence of events in waking life. The word somnambulism is, however, now used in a wider and at the same time more technical sense, being applied to all cases where the individual, either spontaneously or through hypnotic suggestion, falls into an abnormal condition distinguishable from the normal condition of his or her waking life. It is with the alterations of personality exhibited during the state of somnambulism in this wider sense that M. Binet's volume chiefly deals.

The subject is one that is beset with peculiar difficulties, and one in which extreme caution is necessary in drawing anything like definite conclusions. But it is one that is throwing, and is likely to throw, important side light on normal psychology, and one that may prove helpful in elucidating the difficult problem of the nature of the association of brain and consciousness. It will only be possible in the space at our disposal to indicate the nature of some of the evidence M. Binet adduces, and the interpretation suggested by this learned and lucid writer.

The phenomena of so-called spontaneous somnambulism are somewhat as follows. The patient is, we will say, a dull and melancholy young woman. She falls into a deep and prolonged sleep, or suffers from an hysterical or convulsive crisis. On waking from the sleep, or emerging from the crisis, she is in an altered condition, with little or no memory of her previous life, and no apparent knowledge of her friends and relations. Her character is changed: no longer dull and melancholy, she is bright and merry. In this state she remains for a time, learning anew the ways of the world, and daily profiting by her fresh experiences. Then she falls again into deep slumber, or other crisis, from which she emerges her old self once more, taking up her normal dull and melancholy life just where she left it. She remembers nothing that happened in her abnormal or second state. There is no continuity between the two. Such alterations of personality may continue at varying intervals for many years.

Somewhat similar are the phenomena observed in the somnambulism induced through hypnotic suggestion. M. Janet's subject, Léonie, is a serious and rather sad person, calm and slow, very mild with everyone, and extremely timid. Hypnotized, she becomes a different being. She keeps her eyes closed, but her other senses are abnormally acute. She is gay, noisy, and restless; good-natured, but with a tendency to irony and sharp jesting. In this condition she repudiates her former self. "That good woman is not myself," she says, "she is too stupid!"

M. Binet, summarizing the principal modifications of memory in hypnotic somnambulism, says that the subject, during the normal condition, remembers nothing of the events which have taken place during somnambulism, but that, when hypnotized, he may remember not only the occurrences in former somnambulisms, but also those which belong to the normal state. There is thus some continuity of the normal into the hypnotic personality, but none from the hypnotic to the normal. "Le livre de la vie somnambulique se ferme au réveil, et la personne normale ne peut pas le lire."

But though there is no conscious memory in the waking state of what has occurred during somnambulism, it is said to be possible to unseal the register thereof through automatic writing. A fact is told to the subject in the state of somnambulism under hypnosis, and the subject is then restored to the normal state. He has no recollection of the fact, and knows nothing about it. But slip a pencil between his fingers, hiding the hand from his eyes by means of a screen, and he will write down the fact automatically (Gurney).

In cases of so-called "negative hallucination" or "systematic anæsthesia," the subject under hypnotic suggestion neglects and is apparently blind to certain objects. For example, two out of a number of blank cards are marked with a cross, and the subject is made blind to these. If she be given a dozen cards, and among them these two, and if she be asked to count the cards, she will neglect these two and reply that there are ten. But if a pencil be slipped between her fingers, and she be asked in a low voice how many cards there are, she will reply, in automatic writing, *two*. And if she be asked, in the same tone, why she said ten and neglected these two, she will write in reply that "she could not see them."

On the basis of such observations as are here briefly summarized, and others for a description of which we must refer our readers to the book itself, M. Binet contends that, associated with the same physical individual, there may be two (or more) personalities, both of which are conscious. They may be co-existent or successive. Anæsthesia is the barrier which separates co-existent personalities: amnesia the barrier which separates successive personalities. "En un mot, il peut y avoir chez un même individu, pluralité de mémoires, pluralité de consciences, pluralité de personnalités; et chacune de ces mémoires, de ces consciences, de ces personnalités ne connaît que ce qui se passe sur son territoire." We do not propose to discuss this position. Suffice it to say, that for ourselves we see no satisfactory evidence of the *co-existence* of two personalities *both of which are simultaneously conscious*. Strange alterations and modifications of personality may occur under peculiar circumstances; but this is something very different from the supposed co-existence of two or more distinct consciousnesses.

C. LL. M.

OUR BOOK SHELF.

Volcanoes: Past and Present. By Edward Hull, M.A., LL.D., F.R.S. With Forty-one Illustrations and Four Plates of Rock-sections. (London: Walter Scott, 1892.)

IN this new volume of the "Contemporary Science Series," Prof. Hull has given a very readable account of the phenomena of volcanoes and earthquakes. A short introduction to the subject of vulcanology is followed by a sketch of the active and extinct volcanoes of Europe, and this by an account of some of the "dormant or moribund volcanoes of other parts of the world." From this description of recent volcanoes, the author proceeds to the consideration of the Tertiary volcanic districts of the British Islands, and the pre-Tertiary volcanic rocks of our own and other countries. The two concluding chapters of the book are devoted to a consideration of the remarkable eruption of Krakatão in 1883, and the great earthquakes which during the last few years have attracted so much attention, with a discussion of some of the volcanic and seismic problems suggested to the author by his review of the phenomena. These problems are classed by the author under the following heads:—"The Ultimate Cause of Volcanic Action," "Lunar Volcanoes," and the question: "Are we living in an Epoch of special Volcanic Activity?" An appendix gives "A Brief Account of the Principal Varieties of Volcanic Rocks."

In a little book of 270 pages it has of course been impossible for the author to do full justice to such a wide circle of topics, and it is sometimes difficult to detect the principle on which certain subjects have been included, and others rejected by him. But the author may be fairly credited with having accomplished his main object, which he has defined as follows: "To illustrate the most recent conclusions regarding the phenomena and origin of volcanic action by the selection of examples drawn from districts where these phenomena have been most carefully observed and recorded under the light of modern geological science."

An admirable feature of the work is the recognition of the principle that vulcanological problems may often be better attacked by the study of ancient and greatly denuded volcanoes, rather than by the examination of those in actual activity, or of such as have recently become extinct.

"*Encyclopédie scientifique des Aide-mémoire*":—
Résistance des matériaux. Par M. Duquesnay.
Étude expérimentale calorimétrique de la machine à vapeur. Par V. Dwelshauvers-Dery.
Air comprimé ou raréfié. Par Al. Gouilly.
(Paris: Gauthier-Villars, Georges Masson.)

THESE three little hand-books on their respective subjects are made by the separate publication of the respective articles of the "Encyclopédie scientifique"; it is intended that each subject is to appear in a separate volume at a rate of publication of thirty to forty a year.

There is no indication by numbering as to the order of appearance, so that probably these are the pioneer volumes.

The first volume, "La résistance des matériaux," gives a very clear and concise account of the practical side of Elasticity, so far as required by the engineer in the design of beams, columns, bridges, and retaining walls.

Prof. Dwelshauvers-Dery is well known for his theoretical and experimental researches on the Steam Engine, and his treatise may be considered as the application of the empirical laws of saturated vapours to the theoretical determination of the useful effect obtainable in the different forms of steam engine, simple or compound, with an attempt at the evaluation of the loss due to conduction. The results arrived at are checked by comparison with long-continued steam-engine trials carried out by Hirn, Donkin, Longridge, and the author himself.

The third volume, on "Air comprimé," may be supposed to carry out the same development of abstract Thermodynamics when the medium is supposed to behave as a perfect gas. In this case the mathematical laws, developed at the outset, are capable of more ready and immediate application; and the second half of the book gives a detailed account of the employment of air as the medium for the transmission of energy in its various industrial applications—for instance, as laid on in Paris compressed in mains, or as employed when rarefied in the Westinghouse brake.

A useful feature in these books is a page at the outset, in which the notation to be subsequently employed is carefully explained.

The Mechanical Equivalent of Heat is taken as 425 kilogrammetres, presumably at Paris; the mean of Prof. Rowland's experiments gives about 427 Baltimore kilogrammetres, or in absolute measure about 42 million ergs, or 4·2 joules.

The "Encyclopédie" is to be divided in interest between the *section de l'Ingénieur* and the *section du Biologiste;* the volumes promised in the first section, as in course of preparation, will constitute a valuable technical working library. G.

Chambers's Encyclopædia. New Edition. Vol. IX. (London and Edinburgh: W. and R. Chambers, 1892.)

THE new edition of this admirable Encyclopædia is now approaching completion, and in the present volume there is certainly no falling-off in the ability with which the work has hitherto been written and edited. On all important subjects represented by words between "Round" and "Swansea" there are articles summing up the latest results of research. An excellent article on round towers, by Dr. Joseph Anderson, is given on the first and second pages. This is a model of what such a paper ought to be. The author knows his subject thoroughly, and consequently understands where to draw the line between ascertained facts and the theories based upon them. Another well-arranged archæological contribution by Dr. Anderson is the paper on sculptured stones. Dr. John Murray writes with his usual lucidity on the sea and on sounding. The task of expounding the facts and laws relating to sound and to the spectrum has been intrusted to Prof. Knott, and the Rev. E. B. Kirk contributes the articles on the sun and the stars. Dr. Buchan is the author of a clear and interesting paper on storms. Other scientific articles which may be specially noted are those on the Silurian system, by Prof. James Geikie; on the skull, by Dr. D. Hepburn; on the snail and the slug, by Mr. T. D. A. Cockerell; on snakes and spiders, by Mr. J. A. Thomson; on the steam-engine, by Prof. A. B. W. Kennedy; and on the steam-hammer, by Prof. T. H. Beare. Among the geographical contributions are articles on Russia, by Prince Kropotkin; on Siam, by Mr. J. S. Black; on South Australia, by Mr. J. Bonwick; and on Spain, by the Rev. Wentworth Webster.

A Guide to Electric Lighting. By S. R. Bottone. (Whittaker and Co., London, 1892).

IN this work the author gives a general idea of the various methods of electric lighting, without entering into any of those technicalities which tend to confuse rather than enlighten the ordinary reader. Commencing with descriptions of the various batteries that are now employed, he discusses their particular advantages and disadvantages, adding also a table of their E.M.F., currents, and resistances.

The second chapter, which is devoted to the production of currents by means of the dynamo, will enable the reader to form some idea as to the selection of one of these machines for a given purpose, and to understand its general principles. Perhaps the chapter on electric lamps and accumulators will be found the most serviceable, for one is brought far more into contact with them than with dynamos themselves. The information here will enable anyone to set up a small installation for himself, while a very useful table shows the dimensions, capacities, weights, &c., of accumulators suitable for such work.

The remaining chapters deal with the descriptions of some of the smaller appliances necessary in connecting up the supplier of electricity, whether it be dynamo or accumulator, with motors or transformers, and last but not least with an excellent *résumé* of the cost of maintenance, showing the relative prices of gas and electricity as now regulated.

The book contains numerous illustrations, and as a thoroughly practical and handy work should be widely read.

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 Grammar of Science."

To the vast majority of readers, chapter ix. of the "Grammar of Science" will probably seem to be simply a plea in favour of the doctrine of evolution in its purest form. We were not called upon to express any opinion as to the merits of this doctrine, nor did we. What struck us (and still strikes us) as fundamentally illogical, was the formulation of a theory, which, itself avowedly a mental product, proceeded to picture a universe devoid of sentient beings, or, in the phraseology of the "Grammar," a conceptual world evolving the perceptive faculty which creates it. An evolution theory which postulates spontaneous generation and human automatonism is natural to the materialist; and hence our contention that, in spite of the general character of the argument in the earlier chapters of the book, certain conclusions are distinctly materialistic.

Again, we are not of those who would bind down all time to Newton's views on matter, force, and motion. That never has been the position of those whom Prof. Pearson delights in nicknaming the Edinburgh school. Only we think a writer should be careful as to what he imputes to Newton. Thomson and Tait say, "We cannot do better, at all events in commencing, than follow Newton somewhat closely": and unless they have misrepresented the teaching of the "Principia," an attack on their version surely amounts to an attack on Newton. Indeed, Prof. Pearson fully realizes this himself, when, on p. 382, he accuses Newton of thinking of "force in the sense of mediæval metaphysics as a cause of change in motion." It was this statement we took exception to. Similarly, we cannot but look upon Prof. Pearson's obvious jeer at Maxwell's language as of the same gratuitous character.

"Matter is, as it were, the plaything of force"—this evidently Prof. Pearson regards as his trump card. Now these words—and note the "as it were"—occur in the discussion of Newton's laws of motion, and are obviously suggested by Newton's own anthropomorphic language. But they can give rise to no misapprehension in the mind of one who is reading Prof. Tait's "Properties of Matter" for profit. In the light of the introductory chapter there is really no room for other than wilful misrepresentation of Prof. Tait's position. Moreover, it is positively astonishing to find an author, who has no slender claims to the title of historian, confessing his ignorance of Prof. Tait's lecture on "Force," delivered before the British Association in 1876, and published in NATURE, vol. xiv. (see also "Recent Advances," third edition, and Maxwell's "Life," p. 646). That lecture was, we think, the first popular exposition of the subjectivity of force. The recognition of this truth was, of course, a natural consequence of the remarkable series of discoveries which brought home to the mind that energy was physically as objectively real as matter. We certainly did not need to go all the way to Berlin to learn it. C. G. K.

On the Line Spectra of the Elements.

I OBSERVE from Prof. Runge's last letter that on one point I was led into misinterpreting his meaning by his having used the letter j in his second formula on p. 100 (NATURE of June 2) in a sense different from the only definition that had been given of that symbol, viz. the jot of time—the time that light takes to advance one-tenth of a millimetre in the open æther. The period of time represented by j is as determinate as a day or hour. With it, Prof. Runge's equation represents one definite discontinuous motion along the sloping sides of the teeth of a particular saw, and this is what I understood by it. I perceive now that he intended j to be interpreted in a new sense, and meant the equation to represent uniform motion in a straight line to an *indefinite* distance.

If all that Prof. Runge wishes to point out is that motion along an orbit that extends to infinity must be either wholly incapable of being represented by a Fourier's series, or at least must contain a component of that kind, this is both true and obvious; and the instance he gives (which is, in fact, uniform motion to an unlimited distance along a straight line) is a case in point. But it should be added, no such component of the motion of an electric charge which does not yield to Fourier's theorem can produce any periodic disturbance in the æther: in other words, *it would not contribute anything to the spectrum*. Accordingly, any such part of the motion—for instance, the advance, in common with the rest of the solar system, of the electrons within the molecules of a gas on the earth, at the rate of eight miles a second, towards the constellation Hercules, which is the precise kind of motion that Prof. Runge adduces as an instance—has nothing whatever to do with the subject of my memoir, which is an investigation into the cause of double lines *in spectra*. It should further be added that unlimited motions of any kind have nothing to do with motions going on *within molecules*, to the investigation of which chapter iv. of my memoir is devoted, and that any discussion of them there would have been out of place.

Hence, to represent as a defect which vitiates my reasoning, as Prof. Runge does, that I have omitted in that chapter to refer to the motions which are not resolvable by Fourier's theorem, is, I submit, not legitimate criticism, especially as the matter, beside being irrelevant, is obvious; and I also submit that to say "A plausible suggestion about the movement of the molecules ought to explain more than one of the observed phenomena" (NATURE, April 28, p. 607) is not criticism at all. We must use the data furnished by our observation of nature to carry us as far as they will go in the interpretation of nature, and not refuse to employ them to that extent because they do not enable us to get further.

G. JOHNSTONE STONEY.

9 Palmerston Park, Dublin, July 2.

Range of the Sanderling in Winter.

As my little contribution to the *Records of the Australian Museum* has been honoured by a notice in NATURE (*suprà*, pp. 177–78), I must ask leave to qualify two statements therein made. Since I wrote it I have become aware that Dr. Finsch had a specimen of the Sanderling (*Calidris arenaria*) brought to him at Bonham Island, one of the Marshall Group, which lies within the tropics (*Ibis*, 1880, p. 331); and, after the publication of Mr. Everett's list of the birds of Borneo in 1889, that gentleman announced the occurrence of this species at Baram, on the north-east coast of that island (*Ibis*, 1890, p. 465). ALFRED NEWTON.

Magdalene College, Cambridge, June 25.

Immunity of the African Negro from Yellow Fever.

DR. CREIGHTON will find that on p. 51 of a report dated 1890, "On the Etiology and Prevention of Yellow Fever," Dr. George M. Sternberg (Lieut.-Colonel and Surgeon U.S. Army) makes the following statement:—

"It has been asserted that the negro race has a congenital immunity from yellow fever, but this is a mistake. The susceptibility of the negro is, however, much less than that of the white race. Amongst those attacked the mortality, as a rule, is small."

He will also find the subject discussed on pp. 166–67 of "A Contribution to the Natural History of Scarlatina," by Dr. D. Astley Gresswell (Clarendon Press, 1890). Dr. Gresswell writes thus:—

"The African negro of pure descent was supposed to be insusceptible to the virus of yellow fever and of malaria. It is said, however, that when these affections are prevailing in a virulent form the negro does become infected and manifest such infection. This would suggest that the almost complete immunity in the case of the negro has been acquired. Moreover, the fact that negroes of pure descent are more likely to manifest the symptoms of yellow fever on exposure to the poison after they have passed some years or some generations in more temperate latitudes, in which the disease is not indigenous, suggests that in order to maintain this degree of immunity it is necessary that the negro should continue to live in localities in which the virus exists; in other words, that the individual or the race should be repeatedly subjected to the virus. It may, in fact, be questioned how far, in regard to these diseases in man, susceptibility differs independently of protection acquired by previous subjection to the action of the virus or its products; though natural selection may (as certain facts indicate) have acted more directly. Indeed, it is quite possible that protection acquired by previous infection is much more frequently a cause for benignity or only partial susceptibility in the case of these and other infection-diseases than is generally allowed for."

I do not think I can with advantage add anything to these quotations. YOUR REVIEWER.

A Solar Halo.

IN connection with the heavy thunderstorms further south, possibly, there was here the most brilliant solar halo on the 29th which I have seen. The wind was easterly all the time, causing sea-fog-like clouds in the morning, which dissipated by degrees about 10, but I did not notice the halo before 10.45, nor after 3.30 or 4 o'clock. It was certainly gone at 5.

Though a complete halo at 11, it was far intenser above and below, the north-west and south-east octant especially. By 1 o'clock this had shifted to the north-east and south-west octants.

Between 11.45 and 12 the south-east octant of the outer halo (red inside) was also visible.

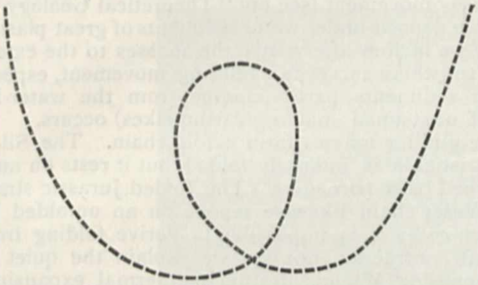
Until 1 o'clock the figure was practically circular, the inner space being remarkably free of colour, the blue of the sky assuming an ashy grey tint. By 2 the figure was elliptical, the long axis horizontal, and the halo *not complete*. The ellipticity increased as the sun sank. Hence the visible part was evidently formed of the *tangent arcs*. No doubt the intense brilliancy near noon was due to these arcs practically coinciding with the ordinary halo, because of the sun's great altitude.

J. EDMUND CLARK.

4 Lorne Terrace, Edinburgh, June 30.

The Electric Current.

DURING the thunderstorm last evening, in the middle of the brilliant flashes which illuminated the south-eastern sky, I noticed the electric current assume the following remarkable form:—



Burlington Fine Arts Club, 17 Savile Row, W., June 29.

EDWARD HAMILTON.

Are the Solpugidæ Poisonous?

AT a recent meeting of the Linnean Society (June 2), I had the honour of exhibiting the jaws, claws, and hairs of a species of Galeodes from Tashkend, in order to show certain peculiarities, which perhaps throw light on the question as to whether these animals are poisonous or not.

Murray, in "Economic Entomology," says: "Their bite is said to be venomous, and even dangerous, but proof of this is wanting."

It is, further, always the natives in both the Old and New Worlds where this "spider" occurs who give it its bad reputation, and always the European immigrant or settler who either doubts or even positively denies it.

In spite of the well-known fact of the persistence of groundless terrors in the minds of uncivilized peoples, I should still be inclined to think that, in a case of this kind, which is one of raw experience, the natives would probably be in the right.

Dufour, in his monograph of the Algerian species (*Mem. p. à l'Institut de France*, xvii.), after describing a serious case arising from a Galeodes bite, having failed to find any poison-glands or apparatus, leaves the mystery to be solved by others.

Croneberg (*Zool. Anzeiger*, 1879) claimed to have discovered the poison gland in a long coiled gland, which he says opens at the tip of a lancet-shaped process at the junction of the palp with its basal or maxillar portion. As far as I can make out, this gland is the homologue of the coxal gland of the other Arachnids. This would not preclude the possibility of its being a poison gland. On the face of it, however, I should not expect to find the opening of the poison gland in this comparatively awkward place. In a creature so armed for attack as Galeodes, one would expect the venom to take a more prominent place in the offensive armoury.

Examination, on immersion in clearing media, shows—

(1) That the tips of the jaws are not only traversed by a canal opening to the exterior, but are covered with multitudes of fine pores, which can be traced with a low power through the thick chitin.

(2) The claws are also open at the tip, while the shaft of the claw seems filled with a glandular mass of tissue provided with tracheæ. These claws are terrible weapons of offence; the articulating joint at the end enables them to anchor themselves in the body of the prey.

(3) Around these claws are sharp hairs, which appear, like the claws, to be open at their tips. It is obvious that the tighter the claws draw themselves into the flesh, the deeper would the pointed hairs at their base penetrate, and, if poisonous, increase the deadly nature of the attack.

(4) Leaving the spines on the limbs, and the long, thin apparently tactile hairs out of account, the hairs on the legs and back are, as a rule, forked at the tip, as has been already described by Dufour. Up to the fork they are hollow, like those round the claws. My suggestion is that these are like buttoned rapiers. They are harmless until the animal is seized. The fork prevents the hair from penetrating until the pressure is great enough to snap off the tip. Small mammals and birds would soon learn not to try to chew up or swallow a Galeodes. If this suggestion is correct, the action of the forked hairs may be compared with that of the stinging hairs of the common nettle.

(5) Here and there are long hollow hairs, with the tips swollen out into a thin bubble-like expansion of the chitin. These hairs may be abnormal. I found five or six in all, and chiefly on the palp. They seem to indicate a tendency of fluid to flow down the hairs.

The openings at the tips of the claws are quite in keeping, morphologically, with those at the tips of the hairs. Claws are but highly developed hairs. The jaws, however, are modified joints of limbs. We have, therefore, to interpret the central canal (?) and the pores which open at and around their tips, as the canals which run through the cuticle into the hairs. We find that, as we recede from the tips of the jaws, the open pores cease, and the hairs commence, each with its central canal continued through the cuticle.

As to the nature of the poison which I suggest flows through these apertures, I am inclined to consider it, in the presumed absence of specialized glands, as a product of the hypodermal cells, perhaps even of those which secrete the hairs themselves. At the tips of the jaws, where the hairs have disappeared and only their pores remain, these cells could be specialized for this purpose alone. In the claws there seems to be a mass of cellular tissue, which would also be a derivative of the hypodermis, and may be solely taken up with the secretion of poison.

One other point remains to be mentioned, viz. the mechanism for the movement of the end joint of the claw. Articulated hairs are common among the Polychæte Annelids, but the exact mechanism is not visible. This large claw of Galeodes may explain these cases. We should naturally not expect a muscle fibre in a hair. The actual mechanism is very simple. Along one side of the claw the chitin splits, for, say, three-fourths of its proximal length, to form an inner and an outer layer. A very slight differentiation of the flexor muscles of the claw would allow of a few fibres being attached to the inner layer. A pull at the inner strip of chitin bends round the tip of the claw, invaginating a small portion of the outer layer, which thus forms a collar round the base of the joint or "nail" as some call it. The bending of the claw would almost necessarily compress its fluid contents, some of which might escape through the opening at its tip.

Until the question as to the poisonous nature of Galeodes has been *experimentally* settled, these observations seem to have some weight in the affirmative scale.

HENRY BERNARD.

Streatham.

Death from Paraffin, and Members of Parliament.

NOTWITHSTANDING the enormous development which has taken place in recent years in gas and electricity, there can be no doubt that oil lamps light the homes of a larger number of persons *throughout the world* than any other illuminant. Even in the United Kingdom alone it has been estimated that over 10,000,000 lamps are in use. No wonder, then, that newspaper readers are every now and again startled by the recital of terrible accidents, too often resulting in agonizing death. Mr. Alfred Spencer, of the London County Council, stated at the inquest on the late Lord Romilly that he estimated that there were 300 deaths a year caused in this country by unsafe lamps. Mr. Shean, of the Fire Brigade Association, expressed the opinion that 10 per cent. of fires are caused by paraffin lamps; and Captain Shaw, the former Superintendent of the London Fire Brigade, reported 156 fires in one year caused by the upsetting of lamps in London. Will a friend to humanity in each constituency ask the candidates, whether Liberal or Conservative, to pledge themselves to support a short Act of Parliament compelling every lamp to have affixed to it an automatic extinguisher, as recommended in the reports of Sir Frederick Abel, Mr. Boverton Redwood, and Colonel Majendie, or must we wait until a Bishop or a Royal Princess is burnt to death?

HUMANITY.

ON THE CAUSES OF THE DEFORMATION OF THE EARTH'S CRUST.

Mountain-making.

By eminent geologists it has been shown that the contraction hypothesis is not sufficient to account for the observed deformations of the earth's crust. We are obliged to look for other causes of deformation.

The form of a cosmic body must be irregular if the masses are unequally mixed. Already in the liquid stage under this condition a geoid is formed. The radius with dense material must be shorter, so much as to equilibrate the higher regions with less density.

This cause of constant irregularity is not sufficient to explain the existing differences of level. In fact, depressions and elevations are not the result of a constant equilibrium; they are not permanent. Sedimentation and erosion disturb the mechanical and the thermal equilibrium and cause a continual deformation of our planet. Another cause of deformation is found in the continual shifting of material. Accumulation of eruptive material and of sediments (loading) on one side, and erosion (disburdening) on the other side, cause deformations of the earth's crust. If the plasticity of the cosmic body is great, the surface of the burdened and disburdened regions has the tendency to remain nearly level—a quasi-hydrostatic (a "magmastatic") equilibrium will dominate.

As the material of our earth is not very plastic, and as other causes of deformation have a contrary effect, it is natural that geological facts are not in accordance with this hypothesis.

Contradictory to this hypothesis are the facts (1) that subsidence does not continue as long as sedimentation goes on; (2) that sinking often is considerable, though the loading is slight; (3) that in many cases enormous loading does not produce a depression of the earth's crust (volcanic chains growing up on a highland).

The Thermal Theory.

The constant disturbance of thermal equilibrium is of the highest importance. Sedimentation causes an ascending movement of the geo-isotherms: expansion and general elevation. If the dilatation is concentrated, there may result a fold-chain (Hall, Reade). The hypothesis is supported by the fact that the elevation and folding always drives up sediments, which were formed immediately before the orogonic movement. The mountains grow up from a shallow sea, they are never generated in the middle of a continent, which might as well occur according to the contraction-hypothesis.

Messrs. Fisher, Hutton, and Reade have considered the thermal effect, and agree that it is sufficient to produce considerable deformations. But to produce a mountain-chain of some 1000 m., we must suppose a concentration of the effect in one zone, as long as we, according to Mr. Reade, consider only the effect of thermal expansion in the earth's crust.

As physical geology considers the earth as a rigid body (the plasticity, according to Mr. G. Darwin, being that of steel) there is no reason why the thermal expansion ought not to proceed through the rigid magma to the region of constant temperature. The increase of temperature being 3° C. for 100 m., the temperature at the depth of 40 km. = 1200° C., at 50 km. = 1500° C. After sedimentation of 10 km. the base of the sediments is warmer by 300°. The underlying masses are equally warmer by this quantity.

The linear expansion of rocks per 100° C. is nearly = 1 per mille, *i.e.* 1 metre per km. In our case the expansion is = 3 m. per km. Lateral expansion being impossible, it results in a vertical elevation of nearly 1 per cent. The *crust* would be elevated through the full expansion by 500 metres.

If we consider the thermal expansion proceeding to a depth of 500 or 1000 km. through the rigid magma, we find that indeed highlands and chains of some 1000 m. may be driven up, even if we do not suppose a concentration of the thermal effect on a restricted zone.

Yet certain facts are not in accordance with the theory thus formulated. (1) Elevation and mountain-making is not a slow and constant process, but it is executed in a short time (relatively). (2) Folding in some cases does not reach to a considerable depth, but we often meet undisturbed masses below the folded complex. These facts induce us to modify the hypothesis.

Messrs. Gilbert and Suess have shown that the movement of folding is horizontal and superficial; we may consequently ask whether folding may not be caused by a *gliding* movement (see my "Theoretical Geology").

If we deposit under water sediments of great plasticity, and if we incline afterwards the masses to the extent of 5° or 10°, there succeeds a gliding movement, especially if the sediments partly emerge from the water-level, and if occasional shaking (earthquakes) occurs.

The gliding masses form a fold-chain. The Silurian of Christiania is intensely folded, but it rests on an undisturbed base (Brögger). The folded Jurassic strata of the Weser chain likewise repose on an unfolded base. In such cases it is impossible to derive folding from a general contraction, nor can we explain the quiet base by supposing a concentration of thermal expansion in certain districts. The existence of a quiet base is explained only if we admit folding to be in such cases a gliding process.

The fact that folding in nature is accompanied by emersion is in accordance with these views.

Contradictory to this hypothesis seems the fact that the hypothetical land (from which the folded sediments were pushed towards the lowland) in the back of the chain is often wanting, and that in its place a (marine or a terrestrial) depression exists. This objection disappears if we pursue the process, and we find that this seemingly contradictory fact indeed must result: partial cooling causes local depression. Erosion has the same effect. If 1 km. (vertical measure) of rock mass is denuded, the temperature of the new surface is lower by 30° C. than it was at this point before erosion occurred. This cooling propagates into depth, and the denuded land gets depressed.

The highland, from which the sediments glide away, must sink down in course of time. The Jura is pushed towards the French plain; in the back is situated the depression of Neuchatel. Here, according to the deduction, existed a highland, which subsided in consequence of cooling. Between the fold-chain and the depressed district are situated deep ruptures, along which earthquakes occur as long as the depression goes on.

East of the Appalachian Mountains, as late as the end of the Palæozoic era, a highland was situated, wherefrom the detritus-masses were transported into the Appalachian sea. Afterwards the Carboniferous emersion occurred (in consequence of thermal expansion) and the Palæozoic sediments were pushed towards the western lowland; here the Appalachian chain was generated. Erosion and consequent cooling, instead of the old elevation, caused a depression in the eastern region, which got inundated by the ocean.

In course of time the adjoining districts have changed parts. In the lowland a chain is driven up and the old highland sinks down.

Eruptive districts form depressions with growing accumulations. The thermal effect in course of time leads to an opposite movement. Material of 1000° C. flows through many fissures and covers the surface. The eruptive region, in consequence, gets heated in a higher degree than by simple sedimentation. The period of depression in this case, too, in course of time, gives way to a contrary movement.

It is obvious that elevation and subsidence, in volcanic as well as in sedimentary districts, must alternate, as we indeed observe. Compression, metamorphism, and loading cause a negative movement in the sedimentary districts (geosyncline); warming causes elevation; erosion again creates subsidence. These positive and negative factors at different times have different values, and partly compensate each other. Therefore elevation and subsidence are often observed to alternate.

The greatest contrasts must occur where a highland joins the sea; here sedimentation and erosion cause a considerable shifting of material; loading and unloading, as well as great thermal contrasts, dominate in these regions.

whole complex begins to glide towards the lowland. The sediments get folded to a considerable depth; faults occurred between districts of diverse motion. The gliding deformation occurred rapidly whenever the base was shaken slightly (earthquakes). The experiment being finished, we let the masses consolidate; afterwards we may prepare profile-cuts, which may be executed with the saw, if we evaporated plaster.

The cuts are instructive, if the strata are differently coloured.

If we mark certain points in the originally level strata, or if we divide the whole system into cubes, we may study the locomotion and deformation of every point, line, square, or cube of our system; the vertical, as well as the horizontal component of displacement, may be observed and measured.

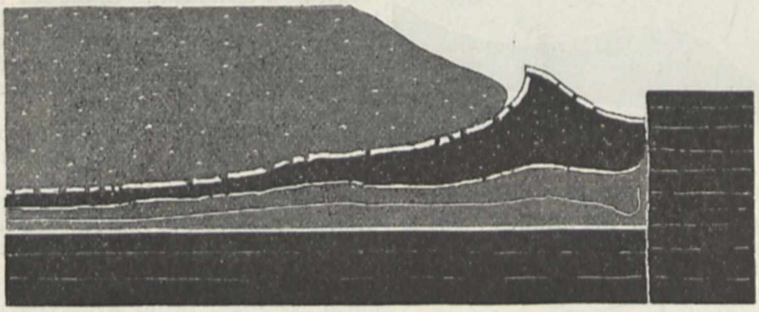


FIG. 1.

The positive and negative movements of the sea-level are not important; but the amplitude of deformation at the boundary between high land and sea is in some cases as great as 20,000 metres.

The hydrosphere is relatively constant, whereas the crust executes oscillations of long duration and great amplitude.

If we want to study in an experiment the formation and motion of a lava-stream, it cannot be our wish to observe the motions of an enormous quantity of a body as viscid and as hot as lava through long time; that would be mere observation, and not experiment. In a real experiment we observe the motion of a small quantity of a less rigid material for some hours or days.

If we observe in nature folded strata of hard sandstone and of soft shale or clay, we shall be satisfied to imitate the deformation of the latter masses; and instead of the hard sandstone, we will take substances as unplastic, but so brittle that they yield to the small forces employed in our experiment.

So we may produce on a small scale, with application of little force and in a short time, the same effect which we observe in nature on a large scale.

If we succeed in producing experimentally the same phases of deformation, the same mechanical effect as in nature, if we see fold-chains and complicated eruptive massives growing up with their characteristic features, we shall be obliged to attribute to these experiments a high importance for mechanical geology.

In my experiments I evaporated muddy material (clay, mud) or plaster of Paris, which consolidates slowly in consequence of an admixture of glue. The strata were differently coloured: some thin strata, consisting of plaster-powder, were brittle, and underwent ruptural deformation, whereas the other masses showed plastic deformation. The whole system reposed on a base, which, according to the plasticity of the material, was inclined by 5° to 15°.

As soon as the inclination attained a certain limit, the

The following experiments explain some points in this theoretical essay:—

The plastic sediments are loaded by a mass, and get deformed in the manner illustrated by Fig. 1. The black base and the black side-wall at the right hand (fault scarp)

FIG. 2.

FIG. 3.

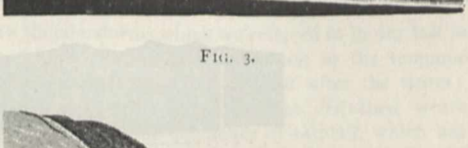


FIG. 4.

are rigid; the plastic strata are pushed up in form of a fold; the highest white stratum is rigid, and gets torn into clods.

Figs. 2-4 show successive stages. A delta, deposited under water, gets elevated, it emerges; the masses are shaken slightly and glide over the inclined base. Folding succeeds, as Figs. 3 and 4 show.

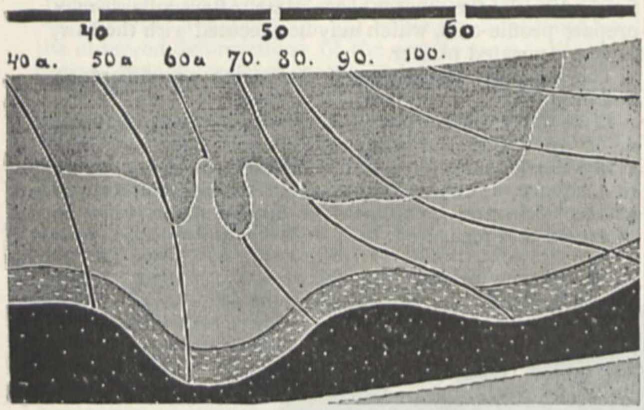


FIG. 5.

In Fig. 5 the strata, gliding over the inclined plane to the left, were divided by vertical lines. Distance of lines = 0·1 metre. At the top of the figure the fixed scale is

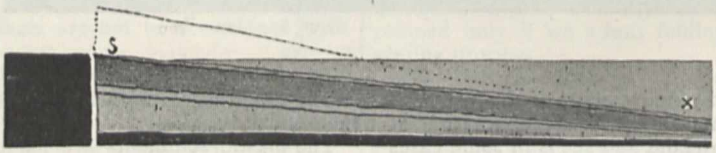


FIG. 6.

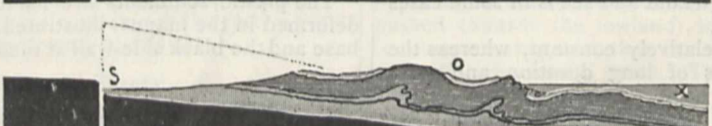


FIG. 7.

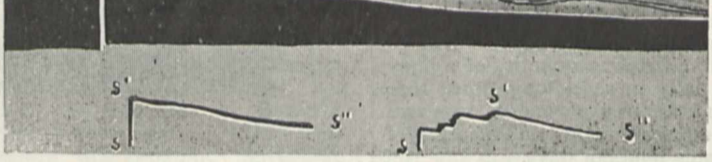


FIG. 8. FIG. 9.

noted. Point 40*a* of the strata originally lay directly below the scale-point 40, 60*a* was placed below 60, and so on.

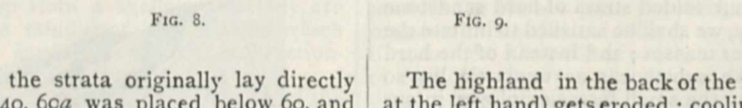


FIG. 10.

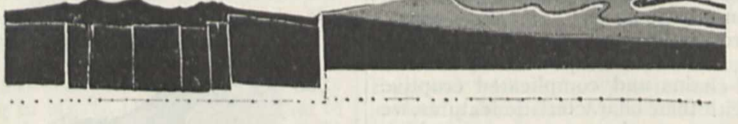


FIG. 11.

We see at once the amount of horizontal (gliding) movement. The vertical lines are deformed in the direction of the motion. The parts near the base move little, the parts near the surface have a higher velocity, so that the vertical lines of division get curved. The motion being intense in the highland (at the right hand), the vertical lines in this region are pushed over and assume a flat position.

The surface of the gliding masses in this case remained level, as the material was very plastic: yet folding in the depth of the masses is remarkable. We see that a fold chain may have a wide surface; the intensely folded regions get exposed only after an extensive erosion or abrasion occurred. This experiment shows also how the motion and the amount of folding decrease in the direction towards the base.

Figs. 6 and 7 illustrate my conception of the process of glide-folding as it occurs in nature. The black parts form the solid basement; at S we observe a fault scarp (the coast of a continent). In the sea the sediments SX are deposited. Warming of the newly-deposited masses, and of the lower parts of the earth's crust, in course of time elevates the sediments, as the dotted line in Fig. 6 notes. The sediments glide over the inclined plane towards the right, and form a fold-chain, O.

The motion of a single point is noted in Fig. 8. Point S first gets elevated (through thermal intumescence) to S′, and then it glides towards S″. In most cases the way described by a point is complicated, as Fig. 9 illustrates. Elevation having reached a certain degree, the masses glide a little, elevation continues, again gliding succeeds, and so on.

The highland in the back of the fold-chain (black mass at the left hand) gets eroded; cooling causes a subsidence of this region, the earth's crust breaks, and through the fissures and faults, in many cases, eruptive material escapes. A volcanic chain is built up in the back of the fold-chain (Fig. 10). In course of time the fold-chain may be covered partly by the volcanic chain (Fig. 11). Fig. 12 (profile), and Fig. 13 (surface of the same experiment) show that pulling (tearing) and pushing (folding) are *reciprocal processes.* The strata, gliding away from the highland, are torn in this district, whereas compression and folding occur in the lowland.

The surface of the strata (Fig. 13) was divided into squares of different colour (like a chess-board), so that

FIG. 12.

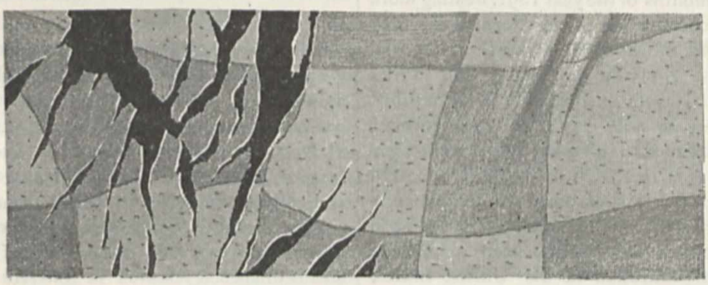


FIG. 13.

we may see and measure directly the direction and amount of pushing and pulling in both districts. Black fissures occur at the left hand, grey folds at the right hand.

The base in this, as in the other cases, was rigid; there occurred *no compression in the depth*, yet folding succeeded in the gliding strata.

Folding, according to my opinion, does not depend on a contraction of our planet, but is a simple gliding phenomenon. E. REYER.

NOTES.

AT the meeting of Section A of the British Association on Monday, August 8, there will be a discussion on the subject of a National Physical Laboratory. The discussion will be opened by Prof. Oliver J. Lodge, F.R.S.

THE Academy of Sciences at Berlin has conferred upon Lord Kelvin one of the first four Helmholtz gold medals.

THE French Association for the Advancement of Science will hold its twenty-first meeting at Pau from September 15 to 22.

THE Council of University College have accepted a tender for the erection of new technical laboratories for the practical teaching of mechanical and electrical engineering. Care has been taken that the buildings shall accord with all the conditions of modern teaching, but of course it is necessary that provision shall also be made for an adequate supply of apparatus and plant. The part of the proposed laboratory which is to be set apart for electrical engineering cannot be properly fitted up for a sum of less than £2010, and Prof. Fleming has issued an appeal to all who may be able and willing to help him in obtaining this amount. In the course of his appeal he says: "The Council do not at present see their way to incur this additional expenditure over and above the cost of the buildings, and yet it is absolutely essential to the completion of the project. The Council have, therefore, by a minute of their proceedings of May 7, 1892, recommended this very essential part of the proposed work to the notice and liberality of those who may be disposed to help. Thus sanctioned and authorized by the Council, the Professor of Electrical Engineering begs permission to bring under your notice the necessity for a special Electrical Apparatus Fund, and desires to invite your aid in the formation of such a fund of £2010, to be entitled 'The University College Electrical Engineering Apparatus Fund.'" Prof. Fleming is anxious that the sum should, if possible, be obtained within the next six months. Donations should be sent to the Secretary of University College, marked "Electrical Apparatus Fund."

THE services rendered by the late Sir William Macleay to the Linnean Society of New South Wales and to science in general are to be commemorated by the publication of a memorial volume. This was decided recently at a general meeting of the New South Wales Linnean Society. It is proposed that, in addition to a portrait and memoir of Sir William Macleay, the volume shall consist of original papers on those branches of science in the advancement of which he was especially interested—zoology, ethnology, botany, and geology. Promises of papers have already been received from Sir F. von Mueller, Prof. Hutton, Prof. J. Parker, Prof. Baldwin Spencer, and other leading Australian biologists. It is intended that, as regards "style of get up and illustration," the volume shall be fully worthy of the occasion. The expense is to be met by means of a public subscription. Every ordinary member of the Society subscribing one guinea or upwards, and any non-member subscribing two guineas or upwards, to the memorial will receive a copy of the volume. At the meeting of the Society on May 25, the President announced that a number of subscriptions had been received in answer to a circular issued a few weeks previously. It was necessary, however, he said, that a considerably larger sum should be collected before the Council would be in a position to proceed with the work.

THE Governors of the Merchant Venturers' School, Bristol, have elected to the vacant Lectureship in Biology Mr. G. P. Darnell-Smith, B.Sc., assistant to Dr. W. Marcet at University College, London. Mr. Smith is a student of University College, and graduated with honours in botany and zoology in 1891.

THE thunderstorms which we referred to in our last issue gave a very decided, but temporary, check to the temperature, the highest day readings falling about 20° after the storm; and the heavy rains which accompanied the disturbed weather have materially lessened the deficiency of rainfall, which has been so characteristic a feature for some months past. By the end of last week the temperature had recovered, and the weather became very fine in the southern parts of the kingdom, the maxima reaching from 80° to 85° at some inland stations on Sunday; while conditions remained unsettled, with heavy rain, in the north and west, owing to a cyclonic area which passed along the Irish coast, and caused a thunderstorm on the east coast. During the last day or two, depressions have passed to the northward of our islands, again causing unsettled weather, with rain in most parts; while the westerly winds have increased considerably in strength, reaching the force of a gale on our north-west coasts.

The *Weekly Weather Report* issued on the 2nd instant shows that the rainfall differed very considerably in various parts; in most of England, the north and west of Scotland, and in Ireland, the amount exceeded the mean. The greatest deficiency on the amount due from the beginning of the year is over the midland, south, and south-west of England, and the west of Scotland, the amounts varying from about 3 to 7 inches. Bright sunshine exceeded the average amount for the week, except in the north-western and south-western districts.

THE Washington Weather Bureau has recently issued a report on its work for the last six months of the year 1891, dealing more with the scientific and practical work of the Department than with the administrative duties, which were referred to in a special report issued in October last (NATURE, vol. xlv. p. 86). Prof. Harrington states that an endeavour has been made to improve the weather forecasts in every possible way; the time covered by the forecasts has been extended to thirty-six hours, and longer in some cases. Every effort is made to distribute the information as widely as possible, and for this purpose the telephone is becoming more popular, and will possibly eventually supersede the telegraph. Increased interest has of late been manifested in regard to meteorological education in the United States, and a list is given of the institutions which announce definite courses of instruction. A very large accumulation of data is now in the possession of the Weather Bureau; a summary of these, under each element, is given in the report, and it is proposed to utilize the materials by special studies to be undertaken by the officers of the Bureau. The study of terrestrial magnetism in connection with meteorology, with the object of discovering some physical relations connecting them, has from time to time been made by various persons, but, on the whole, it has not led to definite results. Prof. Harrington states, however, that the subject is now being specially investigated by Prof. F. H. Bigelow, one of the meteorologists of the Bureau, and that such progress has been made as to render it quite certain that they are intimately associated. By the method of analysis now being used by Prof. Bigelow, which differs from that hitherto employed, it is stated that he has been able to disentangle several of the magnetic fields surrounding the earth, which are observed in the magnetic curves as an integrated effect.

ACCORDING to the *Pioneer Mail*, the Port Officer of Mangalore reports that a native craft was overtaken by heavy weather and made for Mangalore, where there is a bad bar with about eight feet of water in it. A tremendous sea was breaking over the bar, so, before crossing it, and while running in, the native skipper opened one oil cask, forming a part of the cargo, and scattered it all round in the sea plentifully, with the result that he took his craft across the bar safely, and so saved the vessel and the cargo. The vessel's name was *Mahadeprasad*, and she was of 95 tons, bound from Cochin to Bombay. This is said to be the first case on record of a native tindal who has successfully used the oil in troubled waters.

MR. H. ROWLAND-BROWN, writing in the current number of the *Entomologist*, says that when sitting in the Temple Gardens on June 22 he saw a fine male *Colias edusa* fly across the lawn. The excitement among the sparrows was "simply immense," but the butterfly "proved a match for his innumerable pursuers, and sailed calmly over the railings towards the City." The editor of the *Entomologist* adds a note to the effect that this species was seen in London in 1877, which is remembered as the great "*edusa* year."

A FACT noted in the current number of the *Zoologist* gives a very vivid idea of the depth of snow and drift in the north of Scotland last winter. In the parish of Lairg, a month or two after the first thaw set in, two full-grown stags were found dead in a hollow in a "burn." The first thing one of the keepers saw was a stag's antlers above the snow. These he took for the branch of a tree, but on going near he found that a stag had been smothered by the drifting snow while standing on its feet. A week or so afterwards, when more of the snow was melted, another stag was discovered. This one had been smothered while lying down. He was close to his comrade.

THE Peabody Museum has issued, in its series of archæological and ethnological papers, an interesting report on pile-structures in Naaman's Creek, near Claymont, Delaware, by Dr. H. T. Cresson. These pile-structures are believed to be remains of prehistoric fish-weirs.

THE Chicago Exhibition will include what promises to be a very important department for the exhibition of objects relating to ethnology, archæology, history, and cartography. A special bureau connected with the department will represent the history of the Latin-American Republics, and include all relics of the time of Columbus. There will also be a group of "isolated and collective exhibits." A full account of the plan of the department, and of the classification of the exhibits, has been prepared by Mr. F. W. Putnam, chief of the department. By means of special research in different parts of America, under Mr. Putnam's direction, important scientific collections in the ethnological and archæological sections will be brought together. It is hoped that every State Board and many historical and scientific Societies, as well as owners of private collections, will do what they can to contribute to the success of the department, so that it may present a full and effective illustration of the present status of American archæology and ethnology.

MESSRS. MITCHELL AND HUGHES have issued the Transactions of the County of Middlesex Natural History and Science Society for the sessions 1889-90 and 1890-91. The volume contains papers on rabies—its natural history and the means of extinguishing it, by Arthur Nicols; the best means of examining Rotifers under the microscope, by C. Rousselet; the tubercle bacillus, by A. W. Williams; and "A Night among the Infinities," with a description of the instruments at Stanmore Observatory, by Sydney T. Klein.

THE July number of *Natural Science* opens with some "Notes and Comments," and contains articles on "The Story of Olenellus," by Prof. G. A. J. Cole; the physical features of the Norfolk Broads, by J. W. Gregory; the evolution of flatfish, by Prof. A. Giard; is Stigmaria a root or a rhizome? by T. Hick (with "A Reply," by Prof. W. C. Williamson, F.R.S., and "A Rejoinder," by T. Hick); agricultural museums, by J. H. Crawford; and amber and fossil plants, by A. C. Seward.

A PAPER on three deep wells in Manitoba, by Mr. J. B. Tyrrell, was lately submitted to the Royal Society of Canada, and has now been printed in the Transactions. It contains a good deal of interesting and well arranged geological information.

MR. D. J. MACGOWAN, writing in the *Shanghai Mercury*, gives an account of some remarkable statements made by a group of Chinese traders who lately undertook a mercantile exploration of the interior of Southern Formosa. They started from Lamalan, which Mr. Macgowan takes to be Chockeday of the charts, and in seven days reached their objective point, Hualin Stream. They lodged in stone caverns, and the chattering of monkeys and the sounds of insects seemed to them "appalling and indescribable." The region was so "weird" that it reminded them of "legends of the kingdom of hobgoblins." Among the trees were some of "prodigious girth, forming a vast forest." These trees are said to measure more than ten outstretched arms. A tree said to flourish in the same forest is described as bearing "flowers, red and white, which are larger than a sieve, and of extraordinary fragrance." Mr. Macgowan adds:—"Mr. Taylor, while searching for orchids, heard of these majestic trees and huge flowers, which he inferred, from what natives said, were epiphyte orchids. I am moved to make known this sylvan discovery in the hope that, pending the exploration of this *terra incognita* by our botanists, Dr. Henry or Mr. Ford, residents in Formosa, will take measures to provide those naturalists with specimens of flowers, seeds, leaves, and bark of the trees concerning which the Chinese have excited our curiosity."

IN a capital address on "tooth culture," delivered at the annual meeting of the Eastern Counties Branch of the British Dental Association, and printed in the current number of the *Lancet*, Sir James Crichton-Browne referred to a change which has taken place in bread, as one of the causes of the increase of dental caries. So far as our own country is concerned, this is essentially an age of white bread and fine flour, and it is an age therefore in which we are no longer partaking, to anything like the same amount that our ancestors did, of the bran or husky parts of wheat, and so are deprived to a large degree of a chemical element which they contain—namely, fluorine. The late Dr. George Wilson showed that fluorine is more widely distributed in nature than was before his time supposed, but still, as he pointed out, it is but sparingly present where it does occur, and the only channels by which it can apparently find its way into the animal economy are through the siliceous stems of grasses and the outer husks of grain, in which it exists in comparative abundance. Analysis has proved that the enamel of the teeth contains more fluorine, in the form of fluoride of calcium, than any other part of the body, and fluorine might, indeed, be regarded as the characteristic chemical constituent of this structure, the hardest of all animal tissue, and containing 95·5 per per cent. of salts, against 72 per cent. in the dentine. As this is so, it is clear that a supply of fluorine, while the development of the teeth is proceeding, is essential to the proper formation of the enamel, and that any deficiency in this respect must result in thin and inferior enamel. Sir James Crichton-Browne thinks it well worthy of consideration whether the reintroduction into our diet of a supply of fluorine in some suitable natural form—and what form, he asks, can be more suitable than that in which it exists in the pellicles of our grain stuffs?—might not do something to fortify the teeth of the next generation.

THE recent publication is announced of the first number of a new monthly journal under the title *Rivista di patologia vegetale*. It is edited by Sigg. A. N. and A. Berlese, and published at Avellino, in Italy; and is to be devoted to the study of animal and vegetable parasites infesting cultivated plants, to the diseases which they cause, and the remedies employed to combat them.

DR. H. C. CHAPMAN contributes to the latest instalment of the Proceedings of the Academy of Natural Sciences, Philadelphia, a paper describing observations on the brain of the gorilla. He says that while the fissures and convolutions are disposed in the brain of the gorilla in the same manner, generally speaking, as in that of man or of the chimpanzee or orang, it is nevertheless a low type of brain, being much less convoluted than the brain of man or of either of the two other anthropoids. If it were permissible, in the absence of living links or sufficient fossil remains, to speculate upon the development of man and the anthropoids from lower forms of simian life, Dr. Chapman thinks it might be inferred from the character of the brain that the gorilla had descended from some extinct *Cynocephalus*; the chimpanzee and orang from extinct macaque and gibbon-like forms; and man from some generalized simian form combining in itself the characteristics of existing anthropoids.

AT the annual meeting of the Department of Electricity of the Brooklyn Institute of Arts and Sciences on June 1, Prof. E. J. Houston delivered a lecture on recent advances in the applications of electricity. Turning for a moment from the past to the future, Prof. Houston said it was related of Faraday that when asked his opinion of the future of the electric motor, he put up his cane and stopped it. That was Faraday's opinion. Prof. Houston's view was more favourable. The true efficiency of a triple expansion steam engine, he said, did not exceed 17 per cent. as a maximum. With the electric motor we could already get an efficiency of from 90 to 95 per cent., but it was to-day dependent on the steam-engine. A cheaper method would be devised for generating currents, and he believed there were now those living who would see the steam-engine relegated to the scrap heap. Possibly the motor of the future would be operated by thermo-electricity. Possibly a means would be devised of converting the latent energy of coal directly into potential electrical energy. He believed in the successful solution of the problem of aërial navigation in the near future. He was confident that ere long our present methods of electric illumination, in which 97 to 98 per cent. of the energy was expended in useless heat rays, would be supplanted by one in which the order was reversed—in which 97 to 98 per cent. would be converted into light, and but 2 to 3 into heat. And finally, he believed the time was near at hand when electro-therapeutists, instead of regarding the human body as a vehicle for electricity, would regard it as a source of electricity. They would then make their diagnoses with the voltmeter, the ammeter, and the condenser, and the result would then be definite, instead of, as at present, "hit or miss."

THE *Mediterranean Naturalist* quotes a statement made by the late Rev. H. Seddall, who was many years a resident of Malta, as to a curious form of industry formerly practised by the Maltese. "Five species of *Pinna*," wrote Mr. Seddall, "are found in Malta, some of them common in the harbours within reach of a boat or a pole hook. They project from the mud amongst the Zostera roots, to which they are attached by their silken cable. Of this silk, which is of fine texture, but heavy, I have seen gloves made."

THE additions to the Zoological Society's Gardens during the past week include a Palm Squirrel (*Sciurus palmarum*) from India, presented by Miss Daisy Fox; a Common Roe (*Capreolus capræa* ♂), European, presented by Mr. E. J. H. Towers; a Tawny Owl (*Syrnium aluco*), European, presented by Mr. Leigh Robinson; a Bronze Fruit Pigeon (*Carpophaga ænea*) from India, presented by Mr. J. L. Shand; a Tuberculated Tortoise (*Homopus femoralis*), a Tent Tortoise (*Testudo tentoria*), two Fisk's Tortoises (*Testudo fiski*), a Robben Island Snake (*Coronella phocarum*) from South Africa, presented by the Rev. G. H. R. Fisk, C.M.Z.S.; two Green Lizards (*Lacerta viridis*), European, three Viperine Snakes (*Tropidonotus viperinus*) from North Africa, presented by the Rev. F. M. Haines; a Common Chamelon (*Chamæleon vulgaris*) from North Africa, presented by Mr. Samuel L. Bensusan; a Water Viper (*Cenchris piscivora*) from North America, presented by Mr. Ernest Brewerton; a —— Zorilla (*Zorilla typica*), a Grey Monitor (*Varanus griseus*) from Egypt, a Stanley Parrakeet (*Platycercus icterotis*) from Australia, deposited; two Asiatic Wild Asses (*Equus onager* ♂ ♀) from South-west Asia, received in exchange; four Wapiti Deer (*Cervus canadensis* ♂ ♀ ♀ ♀) born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE RED SPOT ON JUPITER.—M. J. J. Landerer, in *Bulletin Astronomique* (tome ix., June), gives the results of his measurements of the dimensions and Jovicentric latitude of the red spot on Jupiter. The method he adopted was to make use of the transit of the satellite's shadows as they were projected on the extreme points of the two axes of the spot, the mean giving the position of the spot's centre. In the case of the third satellite, when its latitude was $-1° 45' 14''$, that of its shadow—reckoning from the bottom side of the spot—was $-30° 34' 36''$. The latitude of the shadow of the second satellite came out to be $-17° 48' 10''$, and after allowing for the fact that it was projected tangentially on the side of the spot and for the diffraction of the instrument, this value for the latitude of the north side of the spot became $-20° 56' 37''$. Taking the mean of the values obtained from both satellites, the latitude of the centre was $-25° 45' 36''$, and, with the polar semi-diameter as unity, the magnitude of the spot was 0·20297.

The mean value of the latitude obtained from eleven observations by Denning, Green, Ricco, Williams, Keeler, and Terby was $21°·5 \pm 2°·05$, the major and minor axes of the spot being 0·555 and 0·188 respectively. Using the micrometer, the latitude, according to Young, amounted to 40°; while Denning estimated that the major axis embraced an arc varying between 29°·3 and 37°·8.

A MEAN TIME SUN-DIAL.—A very ingenious sun-dial, capable of indicating mean time, has been recently invented by Major-General Oliver, the construction of the instrument being undertaken by Messrs. Negretti and Zambra. In an ordinary sun-dial, the time is read off generally by the position of the centre of a shadow, cast by a straight-edged style, on a flat surface on which the hours are graduated. The peculiarity of the present instrument is that the time is indicated by the position of the *edge* of a shadow cast by a "nine-pin" shaped style, with regard to an equatorial circular line. The style is fixed along the diameter of a semicircular arc, which is clamped by means of a screw to a firm stand to suit any latitude; at right angles to this arc, and also capable of adjustment, is another semicircle, graduated in five-minute divisions. Owing to the change of declination of the sun throughout the year, different *parts* of the shadow of the style are brought on to the hour circle in such a way that the difference between the time indicated (by the dial) and mean time, or the equation of time, is counterbalanced by the change in position of the shadow, due to the peculiar form of the style. If we start, for instance, on December 24, the readings have to be taken from the shadow of the eastern edge of the lower part of the style in an upward direction, the bulging out of the style counteracting the increase and decrease of the equation of time (which is here positive) until June 14 is reached. Owing to the thickness of the style's axis, a slight adjustment is here necessary when we pass to the other side of the style; this adjustment is facilitated by placing the twelve o'clock graduation to the western of two marks shown on the vertical circle. This being done, the readings from the shadow, cast now by the western side of the upper protuberance, are taken until the other nodal point on June 14 is reached. At this time also—in fact, four times a year—this slight alteration has to be made. From this latter date until December 24 is reached the same process is repeated, only the respective opposite sides of the style are used in the inverse order. To obviate the necessity of having two styles, which, of course, would have to be the case if the greatest accuracy were desired, owing to the differences in the maximum values of the equation of time, one with a mean contour is given: the error produced by this is practically very slight, amounting in time to about one-sixteenth of greatest value of the equation of time—a quantity scarcely appreciable, on account of the lack of sharpness of the edge of the shadow.

COMET SWIFT (1892 MARCH 6).—*Edinburgh Circular* No. 28 contains a continuation of the ephemeris of Comet Swift (March 6, 1892) for the month of July and part of August, from which we make the following extract:—

Berlin Midnight.

1892.	R.A. h. m. s.	Decl. ° '	log Δ.	log r.	Br
July 7	0 52 36	+48 0·5			
8	53 33	12·6	0·2391	0·2552	0·17
9	54 28	24·5			
10	55 20	36·2			
11	56 10	47·7			
12	56 58	59·0	0·2427	0·2665	0·16
13	57 43	49 10·0			

The brightness at the time of discovery being taken as the unit of brightness, it will be seen that the comet is at present more than five times dimmer than it was in March. In fact, it is rapidly becoming invisible, and will only be able to be observed with large instruments for another two months or so. Its position on July 7 will lie to the very southern extremity of the constellation of Cassiopeia, forming nearly an equilateral triangle with ξ and π.

STARS' PROPER MOTIONS.—Mr. J. G. Porter contributes to the *Astronomical Journal*, No. 268, a catalogue of the proper motions of 301 stars, which amount to half a second or more in a year. This list, as he informs us, is from a still more extensive catalogue which he hopes soon to publish; and the proper motions contained in it are rendered more trustworthy by the enlightenment of new observations. The positions of the stars are all brought up to the epoch 1900·0.

GEOGRAPHICAL NOTES.

M. CHARLES ALLUAUD describes his researches on the Island of Mahé, the largest of the Seychelles Group (see NATURE, p. 162), in a letter to the Paris Geographical Society. He has studied the fauna with some care, and remarks on the singular poverty of animal life compared with the great luxuriance of vegetation. In Port Victoria, the chief settlement in Mahé, the only form of butcher-meat obtainable is the flesh of the great turtle (*Chelone midas*) whose shell is valueless, the tortoise-shell fisheries of the island depending on the *Chelone imbricata*. M. Alluaud hopes to bring back with him living specimens of the elephantine turtles of the Aldabra Islands, specimens of which have been transported to the Seychelles.

THE expectation of an Antarctic expedition, on which valuable scientific observations might have been made, has proved illusory. Captain Gray, of Peterhead, had organized a whaling voyage to the far south, and appealed to the public for funds to carry it out with some prospect of commercial success, but the response was so unsatisfactory that the enterprise has been abandoned. From a scientific point of view, the advantages of Antarctic exploration are so great, and the probability of valuable practical results so apparent, that the apathy alike of the British and Australian Governments as well as of the general geographical public is incomprehensible. The fact that no steamer has ever been despatched to the south of the Antarctic Circle with the object of attaining high latitudes says much for the prudence and little for the energy of present-day explorers.

A CHAIR of Colonial Geography is about to be established at the Sorbonne for the special study of the French colonies.

THE discovery of America by Columbus is to be celebrated in Hamburg on October 11 and 12 by gatherings of delegates from the German Universities and Geographical Societies, by whom papers bearing on German enterprise in the sixteenth century will be read. An exhibition of articles illustrating the early connection of Hamburg and America will also be held.

THE Manchester Geographical Society has just published its *Journal* for July–September 1891, containing several interesting papers on India and a variety of short notices. It is unfortunate that the small local encouragement given to this Society makes the earlier publication of its memoirs impossible. Surely Manchester could afford and should endeavour to maintain a Geographical Society as prosperous financially as it is enterprising and persevering. The contrast between the many provincial Geographical Societies in Germany and France with the three already established in England corresponds to the relative interest in geography as an aid to commerce on the Continent and in Great Britain.

METALLIC CARBONYLS.[1]

JUSTUS LIEBIG, perhaps the most prophetic mind among modern men of science, wrote in the year 1834 in the *Annalen der Pharmacie*. "I have previously announced that carbonic oxide may be considered as a radical, of which carbonic acid and oxalic acid are the oxides, and phosgene gas is the chloride. The further pursuit of this idea has led me to the most singular and the most remarkable results."

Liebig has not told us what these results were, and it has taken many years before the progress of chemical research has revealed to us what may at that early date have been before Liebig's vision. I will to-night bring before you some important

[1] Friday Evening Discourse delivered at the Royal Institution by Ludwig Mond, F.R.S., on June 3.

discoveries made only within the last few years by following up Liebig's idea.

Carbonic oxide, composed of one atom of carbon and one atom of oxygen, is a colourless gas, without taste or smell, which I have here in this jar. It burns with a blue flame. When it acts as a radical combining with other bodies, we term it carbonyl, and its compounds with other elements or radicals are termed carbonyls.

Liebig defined a radical as a compound having the characteristics of a simple body, which would combine with, replace, and be replaced by simple bodies. In more modern times a radical has been defined as an unsatiated body. I am of course speaking of chemical radicals. If we look at it from the modern point of view, carbonyl should be the very model of a radical, because only half of the four valencies of the carbon atom are satiated, the other two remaining free. Carbonic oxide should even be a most violent radical, because, amongst all organic radicals, it is the only one we know to exist in the atomic or free state. All the other organic radicals, even such typical ones as cyanogen and acetylene, are known to us as molecules composed of two atoms of the radical, so that the cyanogen gas and acetylene gas we know should more properly be called di-cyanogen and di-acetylene; they consist of two atoms of the radical cyanogen or of the radical acetylene, the free valencies or combining powers of which satiate or neutralize each other. On the other hand, carbonic oxide gas, as I stated before, makes the sole exception. Its molecule contains only one atom of carbonyl moving about with its free valencies unfettered by a second atom. For all that, carbonic oxide is by no means a violent body, but the very reverse, and instead of being ready to attack with its two free valencies anything coming in its way, until very recently we only knew it to interact and to combine with substances possessing themselves extreme attacking powers, such as chlorine and potassium. Although Liebig had so long ago proclaimed it as a radical, the chemical world was startled when, two years ago, I announced in a paper I communicated to the Chemical Society in conjunction with Drs. Langer and Quincke, that carbonic oxide combines at ordinary temperature with so inactive an element as nickel, and forms a well-defined compound of very peculiar properties.

The fact that carbonic oxide does not possess the chemical activity one would suppose in a radical composed of single atoms may, I believe, be explained by assuming that the two valencies of carbon which are not combined with oxygen do satiate or neutralize each other. Everybody admits that the valencies of two different carbon atoms, which are all considered of equal value, can neutralize each other. I see, therefore, no reason to question the possibility of two valencies of the same carbon atom neutralizing each other. On this assumption carbonic oxide may be looked upon as a self-satisfied body—one which keeps in check its free affinities within itself.

You have here the typical carbon radicals containing one atom of that element, acetylene, methylene, methyl, cyanogen, and carbonyl. In the second column you have these substances as they are known to us in the free state. You see the carbonyl is the only one which exists in the free state as a single atom, while all the others only exist as molecules, composed of two atoms the free valencies of which neutralize each other. The carbonyl I have represented in the last formula, with the two valencies not combined with oxygen neutralizing each other, so that in this way it also becomes a satiated body. I will try to make this still plainer to you by means of the models I have before me.

The paper published by Liebig in 1834, from which I have already quoted, was entitled "On the Action of Carbonic Oxide on Potassium." In it Liebig fully described the preparation and properties of the first metallic carbonyl known—a compound of potassium and carbonic oxide. Liebig obtained this compound by the direct action of carbonic oxide upon potassium at a temperature of 80° C., and proved it to be identical with a substance which had been previously obtained as a very disagreeable by-product of the manufacture of potassium from potash and carbon by Brunner's method. It forms a grey powder which is not volatile, and which on treatment with water yields a red solution, gradually turning yellow in contact with air, and from which on evaporation a yellow salt is obtained, called potassium croconate, on account of its colour. Liebig showed this salt to consist of two atoms of potassium, five of carbon, and five of oxygen, and not to contain any hydrogen, as had previously been supposed.

Since the publication of Liebig's paper, potassium carbonyl has been studied by numerous investigators, amongst whom Sir Benjamin Brodie deserves particular mention; but it has been reserved to Nietzki and Benkiser to determine finally in the year 1885, by a series of brilliant investigations, its exact constitution, and its place in the edifice of chemistry. They have proved that it has the formula $K_6C_6O_6$; that the six carbons in this compound are linked together in the form of a benzole ring; that, in fact, the compound is hexhydroxylbenzole, in which all the hydrogen is replaced by potassium. By simple treatment with an acid it can be converted into the hexhydroxylbenzole, and from this substance it is possible to produce, by a series of reactions well known to organic chemists, the whole wide range of the benzole compounds. The body which Liebig obtained by the direct action of carbonic oxide on potassium has thus enabled us to prepare synthetically in a very simple way from purely inorganic substances—to wit, from potash and carbon, or if we like even from potash and iron—the whole series of those most important and interesting compounds called aromatic compounds, including all the coal-tar colours, which have furnished us with an undreamt-of variety of innumerable hues and shades of colour, as well as many new substances of great value to suffering humanity as medicines. Surely a startling result, which alone would have fully justified Liebig's prediction of 1834!

Speaking of coal-tar colours, everybody will be reminded of the great loss the scientific world has recently sustained by the death of August Wilhelm Hofmann, their first discoverer, Liebig's greatest pupil. Hofmann will ever be remembered in this Institution, where he so often delighted the audience by his lucid lectures, and in whose welfare he took the greatest interest, of which he gave us a fresh proof only last year, in the charming letter he wrote on the occasion of his election as an honorary member.

Looking back upon the wonderful outcome of Liebig's idea I have referred to, it seems surprising indeed that others should not have followed up his work by attempting to obtain other metallic carbonyls.

A very few experiments were made with other alkaline metals: sodium, otherwise resembling potassium so closely, has been shown not to combine with carbonic oxide; lithium and cæsium are stated to behave similarly to potassium. But metals of other groups received little or no attention. The very important *rôle* which carbonic oxide plays in the manufacture of iron did lead a number of metallurgists (among whom Sir Lowthian Bell and Dr. Alder Wright are the most prominent) to study its action upon metallic iron and other heavy metals, including nickel and cobalt at high temperatures. They proved that these metals have the property to split up carbonic oxide into carbon and carbonic acid at a low red heat, a result of great importance, which threw a new light upon the chemistry of the blast furnace. None of these investigators, however, turned their attention to obtaining compounds of these metals with carbonic oxide, and, owing to the high temperature and the other conditions under which they worked, the existence of such compounds could not come under their observation. In order to obtain these compounds, very special conditions must be observed, which are fully described in the papers I have published during the last two years in conjunction with Dr. Langer and Dr. Quincke.

The metals must be prepared with great care, so as to obtain them in an extremely fine state of division, and must be treated with carbonic oxide at a *low temperature*. The best results are obtained when the oxalate of the metal is heated in a current of hydrogen at the lowest temperature at which its reduction to the metallic state is possible. I have in the tube before me metallic nickel prepared in this way, and over which a slow current of carbonic oxide is now passing; the carbonic oxide before entering the tube burns, as you see, with a blue non-luminous flame. After passing over the nickel it burns with a highly luminous flame, which is due to the separation of metallic nickel from the nickel carbonyl formed in the tube, which is heated to incandescence in the flame. (In passing the gas issuing from our tube through a glass tube heated to about 200°, we obtain a metallic mirror of pure nickel, because at this temperature the nickel carbonyl is again completely resolved into its components, nickel and carbonic oxide. If we pass the gas through a freezing mixture, you will observe that a colourless liquid is condensed, of which I have a larger quantity standing in this tube. This liquid formed is pure nickel carbonyl, and has the formula $Ni(CO)_4$.

If cooled to − 25° C., it solidifies, forming needle-shaped crystals. The vapour of nickel carbonyl possesses a characteristic odour and is poisonous, but not more so than carbonic oxide gas. Prof. McKendrick has studied the physiological action of this liquid, and has found that, when injected subcutaneously in extremely small doses in rabbits, it produces an extraordinary reduction in temperature, in some cases as much as 12°.

The liquid can be completely distilled without decomposition, but from its solution in liquids of a higher boiling-point it cannot be obtained by rectification. On heating such a solution the compound is decomposed, nickel being separated in the liquid, while carbonic oxide gas escapes. I will try to demonstrate this by an experiment.

We have here a solution of the substance in heavy petroleum oil, which you will, in a few minutes, see turns completely black on heating by the separation of nickel, while a gas escapes which is carbonic oxide.

In a similar way, when the nickel carbonyl is attacked by oxidizing agents, such as nitric acid, chlorine, or bromine, it is readily broken up, nickel salts being formed, and carbonic oxide being liberated. Sulphur acts in a similar way. Metals, even potassium, alkalies, and acids, which have no oxidizing power, will not act upon the liquid at all, nor do the salts of other metals react upon it. The substance behaves therefore, chemically, in an entirely different manner from potassium carbonyl, and does not lead, as the other does, by easy methods to complicated organic compounds. It does not show any one of the reactions which are so characteristic for organic bodies containing carbonyl, such as the ketones and quinones; and we have not been able, in spite of very numerous experiments, either to substitute the carbonic oxide in this compound by other bivalent groups, or to introduce the carbonic oxide by means of this compound into organic substances.

By exposing the liquid to atmospheric air, a precipitate of carbonate of nickel is slowly formed of varying composition, which is yellowish-white if perfectly dry air is used, and varies from a light green to a brownish colour if more or less moisture is present. We have found all these precipitates to dissolve easily and completely in dilute acid, with evolution of carbonic acid, leaving ordinary nickel salts behind, and can therefore not agree with the view propounded by Prof. Berthelot, in a communication to the French Academy of Sciences, that these precipitates contain a compound of nickel with carbon and oxygen, comparable to the so-called oxides of organo-metallic compounds. In the same paper Prof. Berthelot has described a beautiful reaction of nickel carbonyl with nitric oxide, which we will now show you. You will notice the intense blue coloration which the liquid solution of nickel carbonyl in alcohol assumes by passing the nitric oxide through it. Prof. Berthelot has reserved to himself the study of this interesting body, but has so far not published anything further about it.

The chemical properties of the compound I have just described to you are without parallel; we do not know a single substance of similar properties. It became, therefore, of special interest to study the physical properties of the compound.

Prof. Quincke, of Heidelberg, has kindly determined its magnetic properties, and found that it possesses in a high degree the property discovered by Faraday, and called by him diamagnetism, which is the more remarkable, as all the other nickel compounds are paramagnetic. He also found that it is an almost perfect non-conductor of electricity, in this respect differing from all other nickel compounds.

The absorption spectrum, and also the flame spectrum, of our compound are at present under investigation by those indefatigable spectroscopists, Profs. Dewar and Liveing, by whose kindness I am enabled to bring before you, in advance of a paper they are sending to the Royal Society, some of the interesting results they have obtained. We have here a photograph of the absorption spectrum, obtained by means of a hollow prism through quartz plates filled with nickel carbonyl, through which the spark spectrum of iron is passed, which is photographed on the same plate. You see that the whole of the ultraviolet rays of the iron spectrum have disappeared, being completely absorbed by the nickel carbonyl, which is thus quite opaque for all the rays beyond the wave-length 3820. The spectrum of the highly luminous flame of nickel carbonyl, which I have shown you before, is quite continuous; but if the nickel carbonyl is diluted with hydrogen, and the mixture burnt by means of oxygen, the gases burn with a bright yellowish-green flame without visible smoke; and the spectrum of this flame shows in its visible part, on a background of a continuous spectrum, a large number of bands, brightest in the green, but extending on the red side beyond the red line of lithium, and on the violet side well into the blue. These bands cannot be seen on the photograph which I will now show you, the visible part of the spectrum appearing continuous; but beyond the visible part the photograph shows a large number—over fifty—of well-defined lines in the ultra-violet. I will show you these lines in another photograph taken with greater dispersion, and on which has also been photographed the spark spectrum of nickel. You will see that all these lines correspond absolutely to lines appertaining to the spark spectrum; in fact, the greater part of the lines in the spark spectrum are also shown in this flame spectrum. We have here another and very striking example of the fact discovered on the same day by Profs. Dewar and Liveing, and by Dr. Huggins, that the spectrum of luminous flames is not always continuous throughout its whole range, a fact which was at one time much debated and discussed.

One of the most remarkable discoveries made within the precincts of this Institution by that illustrious man whose centenary we celebrated last year was that of the connection between magnetism and light, which manifests itself when a beam of polarized light is sent through a substance while it is subjected to a strong magnetic field, under whose influence the beam of light is rotated through a certain angle. Dr. W. H. Perkin has prosecuted this discovery of Faraday's by a long series of most elaborate researches, and has established the fact that this power of magnetic rotation of various bodies has a definite relation to their chemical constitution, and enables us to gain a better insight into the structure of chemical compounds. Dr. Perkin has been good enough to investigate the power of magnetic rotation of the nickel carbonyl, and has found it quite as unusual as its chemical properties, and to be, with the sole exception of phosphorus, greater than that of any other substance he has yet examined.

The power of different bodies of refracting and dispersing a ray of light has been shown by the beautiful and elaborate researches undertaken many years ago by Dr. Gladstone—who has given an account of them in this theatre in 1875, and who has since continued them with indefatigable zeal—to throw a considerable light upon the constitution of chemical compounds.

I have investigated the refractive and dispersive powers of nickel carbonyl in Rome, in conjunction with Prof. Nasini. We found that the atomic refraction of nickel in the substance is nearly two and a half times as large as it is in any other nickel compound—a difference very much greater than had ever before been observed in the atomic refraction of any element. To give you some idea how these figures are obtained, Mr. Lennox will now throw on to the screen a beam of light through two superposed prisms, one filled with nickel carbonyl and the other with alcohol. You will notice that the lines of the spectrum on the top are turned much further to the left, showing the nickel carbonyl to possess a much greater power of refraction than alcohol, and you will also notice that it is much wider than the bottom spectrum, which shows the greater dispersive power of the nickel carbonyl.

It is now generally supposed that, if one element shows different atomic refractive powers in different compounds, it enters with a larger number of valencies into the compound which shows a higher refractive power. In accordance with this view, the very much greater refractive power of the nickel in the carbonyl would find an explanation in assuming that this element, which in all its other known combinations is distinctly bivalent, exercises in the carbonyl the limit of its valency, viz. 8, assigned to it by Mendeleeff, who placed it in the eighth group in his Table of Elements. This would mean that the one atom of nickel contained in the nickel carbonyl is combined directly with each of the four bivalent atoms of carbonyl, each of which would saturate two of the eight valencies of nickel, as is shown by this formula—

$$\begin{array}{ccccc} & & O & & \\ & & \vdots & & \\ & & C & & \\ & & \| & & \\ O:C & = & Ni & = & C:O \\ & & \| & & \\ & & C & & \\ & & \vdots & & \\ & & O & & \end{array}$$

This view seems plausible, and in accordance with the chemical properties of the substance, and I should have no hesitation in accepting it if we had not, in the further pursuit of our work on metallic carbonyls, met with another substance—a liquid compound of iron with carbonic oxide—which in its properties bears so much resemblance to the nickel compound that one cannot assign to it a different constitution, whilst its composition makes the adoption of a similar structural formula next to impossible. It contains, for one equivalent of iron, five equivalents of carbonyl. To assign to it a similar constitution, one would, therefore, have to assume that iron did exercise ten valencies, or two more than any other known element, a view which very few chemists would be prepared to countenance. The atomic refraction of iron in this compound, which Dr. Gladstone has had the kindness to determine, is as unusual as that of the nickel in the nickel compound, and bears about the same ratio to the atomic refraction of iron in other compounds. We have, therefore, to find another explanation for the extraordinarily high atomic refraction of these metals in their compounds with carbon monoxide, which may possibly modify our present view on this subject. As to the structure of these compounds themselves, we are almost bound to assume that they contain the carbonyl atoms in the form of a chain.

The ferro-carbonyl is prepared in a similar manner to the nickel compound. The iron used is obtained by heating iron oxalate at the very lowest temperature possible. This carbonyl forms, however, with such very great difficulty, that we overlooked its existence for a long time, and great precautions have to be taken to obtain even a small quantity of it. It forms an amber-coloured liquid, of which I have a small quantity before me. It solidifies below − 21° C. to a mass of needle-shaped crystals. On heating the vapour to 180° C., it is completely decomposed into iron and carbonic oxide. The iron mirrors before me have been obtained in this way. Its chemical composition is $Fe(CO)_5$.

It is interesting that, within a short time after we had made known the existence of this body, Sir Henry Roscoe found it in carbonic oxide gas which had stood compressed in an iron cylinder for a considerable time, and expressed the opinion that the red deposit which sometimes forms in ordinary steatite gas-burners is due to the presence of this substance in ordinary illuminating gas. Its presence in compressed gas used for lime-lights has been noticed by Dr. Thorne, whose attention was called to the fact that this gas sometimes will not give a proper light because the incandescent lime becomes covered with oxide of iron.

M. Garnier, in a paper communicated to the French Academy of Sciences, supposes even that this gas is sometimes formed in large quantities in blast-furnaces when they are working too cold, and refers to some instances in which he found large deposits of oxide of iron in the tubes leading away the gas from these furnaces. I find it difficult to believe that the temperature of a blast-furnace could ever be sufficiently reduced as to give rise to the formation of this compound. On the other hand, it is highly probable that the formation of this compound of iron and carbonic oxide may play an important *rôle* in that mysterious process by which we are still making, and have been making for ages, the finest qualities of steel, called the cementation process.

The chemical behaviour of the substance towards acids and oxidizing agents is exactly the same as that of the nickel compound, but to alkalies it behaves differently. The liquid dissolves without evolution of gas. After a while a greenish precipitate is formed, which contains chiefly hydrated-ferrous oxide, and the solution becomes brown. On exposure to the air, it takes up oxygen; the colour changes to a dark red, whilst hydrated ferric oxide separates out.

We have so far not been able to obtain from this solution any compound fit for analysis, and are still engaged upon unravelling the nature of the reaction that takes place, and of the compounds that are formed.

Although the solution resembles in appearance to some extent the solutions obtained by treating potassium carbonyl with water, it does not give any of the characteristic reactions of the latter.

When speaking of potassium carbonyl, I mentioned that, by its treatment with water, croconate of potassium was obtained, which has the formula $K_2C_5O_5$. We have transformed this by double decomposition into ferrous croconate (FeC_5O_5), a salt forming dark crystals of metallic lustre resembling iodine, which is not volatile, and dissolves readily in water, the solution giving all the well-known reactions of iron and of croconic acid. You will note how entirely different the properties of this substance are from those of iron carbonyl, which I have described to you; yet, on reference to its composition, you will find that it contains exactly the same number of atoms of iron, carbon, and oxygen as the latter. This is a very interesting case of isomerism, considering that both compounds contain only iron, carbon, and oxygen.

The difference in the properties of these two bodies becomes explainable by comparing the structural formula of the two substances.

I would now call your attention to the great difference in the constitution of the potassium carbonyl and that of the nickel and ferro carbonyl. In the former the metal potassium is combined with the oxygen in the carbonyl; in the latter the metals nickel and iron are combined with the carbon of carbonyl. In the first case we have a benzole ring with its three single and three double bonds; in the second a closed chain with only single bonds. It is evident that the chemical properties of these substances must be widely different.

The ferro-penta-carbonyl remains perfectly unchanged in the dark, but if it is exposed to sunlight it is transformed into a solid body of remarkably fine appearance, of gold colour and lustre, as shown by the sample in this tube.

This solid body is not volatile, but on heating it in the absence of air, iron separates out and liquid ferro-carbonyl distils over. If, however, it is heated carefully in a current of carbonic oxide it is reconverted into the ferro-penta-carbonyl, and completely volatilized. We have so far found no solvent for this substance, so that we have no means as yet of obtaining it in a perfectly pure state. Several determinations of the iron in different samples of the substance have led to fairly concordant figures, which agree with the formula $Fe_2(CO)_7$, or di ferro-hepta-carbonyl.

The interesting properties of the substances described have naturally led us "to try," as Lord Kelvin once put it to me so prettily, "to give wings to other heavy metals." We have tried all the well-known and a very large number of the rarer metals; but with the exception of nickel and iron we have so far been entirely unsuccessful. Even cobalt, which is so very like nickel, has not yielded the smallest trace of a carbonyl. This led me to study the question whether, by means of the action of carbonic oxide, the separation on a large scale of nickel from cobalt could not be effected, which has so far been a most complicated metallurgical operation; and subsequently I was led to investigate whether it would not be possible to use carbonic oxide to extract nickel industrially direct from its ores.

It had been established that pure nickel prepared with very great precautions in a glass tube, could be partly volatilized by carbonic oxide, and that from the gas thus obtained the nickel could be separated again by heating. The questions to be studied were, therefore, whether it would be possible to reduce the ores, on an industrial scale, under such conditions as to obtain the nickel in a sufficiently finely divided and active a state that the carbonic oxide would volatilize it; whether such action would be sufficiently rapid to allow of its industrial application; whether it would be sufficiently complete to remove all the nickel from the ore; and whether none of the other constituents of the ore would pass with the nickel and render it unfit for use; and further, whether the nickel could be completely separated out of the gas within practical limits; and whether the recovered carbonic oxide could be made use of over and over again.

For solving these problems within the limits of the resources of a laboratory, I have devised apparatus which consists of a cylinder divided into many compartments, through which the properly prepared ore is passed very slowly by means of stirrers attached to a shaft. On leaving the bottom of this cylinder, the ore passes through a transporting screw, and from this to an elevator, which returns it to the top of the cylinder, so that it passes many times through the cylinder, until all the nickel is volatilized. Into the bottom of this cylinder we pass carbonic oxide, which leaves it at the top charged with nickel carbonyl vapour, and passes through the conduits shown here into tubes set in a furnace and heated to 200°. Here the nickel separates out from the nickel carbonyl. The carbonic oxide is regenerated and taken back to the cylinder by means of a fan, so that the same gas is made to carry fresh quantities of nickel out of the ore in the cylinder, and to deposit it in these tubes an infinite number of times.

Upon these principles Dr. Langer has constructed a complete plant on a Liliputian scale, which has been at work in my laboratory for a considerable time, and a photograph of which we will now throw on to the screen. You see here the volatilizing cylinder divided into numerous compartments, through which the ore is passing, and subjected to the action of carbonic oxide. At the bottom the ore is delivered into the transporting screw, passing through a furnace, and from this screw into an elevator, which returns the ore to the top of the cylinder, so that the ore constantly passes at a slow rate through the cylinder again and again, until the nickel it contains has been taken out. The carbonic oxide gas, prepared in any convenient manner, enters the bottom of the cylinder and comes out again at the top. It then passes through a filter to retain any dust it may carry away, and thence into a series of iron tubes built into a furnace, where they are heated to about 200° C. In these tubes the nickel carbonyl carried off by the carbonic oxide is completely decomposed, and the nickel deposited against the sides of the tubes is from time to time withdrawn, and is thus obtained in the pieces of tubing and the plates which you see on the table.

The carbonic oxide regenerated in these tubes is passed through another filter, thence through a lime purifier, to absorb any carbonic acid which may have been formed through the action of the finely-divided nickel upon the carbonic oxide, and is then returned through a small fan into the bottom of the cylinder. The whole of this plant is automatically kept in motion by means of an electric motor, and the gearing which you see here.

By means of this apparatus we have succeeded in extracting the nickel from a great variety of ores, in a time varying, according to the nature of the ore, between a few hours and several days.

Before the end of this year this process is going to be established in Birmingham on a scale that will enable me to place its industrial capacity beyond a doubt, so that I feel justified in the expectation that in a few months nickel carbonyl, a substance quite unknown two years ago, and to-day still a great rarity, which has not yet passed out of the chemical laboratory, will be produced in very large quantities, and will play an important *rôle* in metallurgy.

The process possesses, besides its great simplicity, the additional advantage that it is possible to immediately obtain the nickel in any definite form. If we deposit it in tubes we obtain nickel tubes; if we deposit it in a globe we obtain a globe of nickel; if we deposit it in any heated mould we obtain copies of these moulds in pure, firmly coherent, metallic nickel. A deposit of nickel reproduces the most minute details of the surface of the moulds to fully the same extent as galvanic reproductions. All the very numerous objects now produced by galvanic deposition, of which Mr. Swan exhibited here such a large and beautiful variety a fortnight ago, can thus be produced by this process with the same perfection in pure metallic nickel. It is equally easy to nickel-plate any surface which will withstand the temperature of 180° C. by heating it to that temperature and exposing it to the vapour, or even to a solution of nickel carbonyl, a process which may in many cases have advantages over electroplating. I have on the table before me specimens of nickel ores we have thus treated, of nickel tubes and plates we have obtained from these ores, and a few specimens of articles of pure nickel and articles plated with nickel which have been prepared in my laboratory. These will give you some idea of the prospects which the process I have described opens out to the metallurgist, upon whom, from day to day, greater demands are made to supply pure nickel in quantities. The most valuable properties of the alloy of nickel and iron called nickel-steel, which promises to supply us with impenetrable ironclads, have made an abundant and cheap supply of this metal a question of national importance. The inspection of the few specimens of articles of pure nickel and of nickel-plated articles will, I hope, suffice to show you the great facilities the process offers for producing very fine copies, and for making articles of such forms as cannot be produced by hydraulic pressure, the only method hitherto available for manufacturing articles of pure nickel.

The first practical use of the process has been made by Prof. Ramsay, who, for the purposes of a chemical investigation, made this beautiful little apparatus of pure nickel all in one piece, which he has kindly lent for exhibition to-night.

I began my lecture by bringing under your notice an idea of Liebig's which he published fifty-eight years ago. I have shown you how he himself elaborated this idea, and how it developed, until within recent years it has led to results of the highest scientific importance and probably of great practical utility.

Had Liebig all these results before his "mind's eye" when he penned those prophetic words I have quoted? This is a question impossible to answer. Who will attempt to measure the range of vision of our great men, who from their lofty pinnacle see with eagle eye far into the Land of Science, and reveal to us wonderful sights which we can only realize after toiling slowly along the road they have indicated? Whether Liebig saw all these results or not, it is due to him and to men like him that science continues its marvellous advance, dispersing the darkness around us, and ever adding to the scope and exactness of our knowledge, that mighty power for promoting the progress and enhancing the happiness of humanity.

NORTH-WESTERN DISTRICT OF BRITISH GUIANA.

At the meeting of the Royal Geographical Society on Monday evening, Mr. Everard im Thurn described the general characteristics of the new district in the north-west of British Guiana in the settlement and administration of which he has been employed for the last nine years. The colony of British Guiana he described as formed of a low swampy coast strip, often below the level of the sea, densely covered with mangroves, and intersected by rivers bound together by interlacing channels. Farther inland the mangroves pass into forests of tropical trees, which, as the land rises more steeply, are reduced to strips along the rivers, and finally merge into dry grassy uplands known as savannahs. The north-western district of the colony is officially defined as the territory bounded on the north by the Atlantic Ocean and the mouth of the River Orinoco; on the south by the ridge of land between the sources of the Amakuru, Barima, and Waini Rivers, and their tributaries, and the sources of the tributaries of the Cuyuni River; on the east by a line extending from the Atlantic Ocean in a southerly direction to the said ridge of land; on the south and on the west, by the Amakuru River and the line known as Schomburgh's line.

Mr. im Thurn's first task was to explore his territory, and this he did mainly by boat along the rivers and their connecting channels, traversing country never before visited by white men. The nature of this mode of travelling was very vividly described. On ascending the Moruka, the country on each side of the river was seen to become gradually more and more open—the river at last often winding through open savannahs, and broadening out here and there into pools so thickly set with water-lilies that the boat was forced through with difficulty. The waterway after some time leaves the river and passes along a narrow itabbo, or artificial water-path, which connects the Moruka with the Waini River. This connecting passage is about thirty miles long, and about ten miles is semi-artificial itabbo, made by the constant passage of the canoes of the Redmen through the swampy savannah, and very difficult to get through. Generally, it was hardly wider than the boat, and had many abrupt windings; the trees hung down so low over the water, that it was hard work either to force the boat under the low-lying branches, or to cut these away, and so make a passage. On either side of the channel the ground is so swampy as rarely to allow foothold of even a few inches in extent. The light hardly penetrates through the dense roof of leaves; and in the gloom under the roof only a few aroids, ferns, lilies, and orchids, and great masses of a palm previously undescribed could be described.

The itabbo passed, the boat turned suddenly into the Barabara River itself, at first narrow, but soon widening and winding on its course through dense and unbroken bush, chiefly composed of the graceful, swaying manicole palms (*Euterpe edulis*). Very abundant, perched high up and low down among this dense bush, were great quantities of an orchid with stems eight and nine feet long, loaded with its countless butterfly-like yellow flowers (*Oncidium altissimum*). After a few miles the Barabara River led into the Biara, a river of much the same character, which, though naturally larger than the Barabara, was still so small as hardly to deserve more than the local name of creek. And, again, in a few miles the Biara carried the boat into the Baramanni River, which is about 100 or 150 yards wide, and very deep. This is, in fact, not a river at all, but a very elongated lake or lagoon, of perhaps twenty miles in length, the lower end opening into the Waini, while the upper end discharges part of its surplus water into the sea. Anything more maze-like than the itabbo between the Waini and Barima Rivers it is impossible to imagine.

On the Aruka, a large tributary of the Barima, the curious Arawack game of the Macquari whip is played, the essential feature of which is a testing of endurance by means of alternately giving and receiving severe cuts with a somewhat severe whip. This extraordinary performance, accompanied with much drinking and with invariable good humour, is carried on for some days in accordance with a fixed ritual, the blows, which are received by the players on the calves of their legs, being so severe as to draw much blood. The river, too, must at one time have been the site of a Redskin civilization far superior to, and very different from, any known previously of the early inhabitants of Guiana; for there are on it considerable deposits of pottery ornamented with incised patterns, and even very abundantly with grotesque figures of men and animals in very high relief. To estimate the significance of this latter fact, it must be remembered that none of the known early inhabitants of Guiana have advanced in the important primitive art of pottery beyond the stage of making vessels of two or three definite and very simple shapes, which are almost invariably entirely without ornament, or are at best, in a very few cases, ornamented with a simple pattern painted on the flat surface.

The Warrau Redmen inhabiting a neighbouring region have recourse to a picturesque game in order to decide disputes amicably. For this purpose, on an appointed day both parties come together on some open space, such as this sand-bank, each man or boy provided with a large shield made of the leaf-stalks of the aeta palm (*Mauritia flexuosa*). After much shouting and dancing in two opposed lines, the shields of the one party are pushed against those of the other, and by this means the members of each party endeavoured by sheer strength to overthrow, or at least to force back from their position, the members of the other party; and the right in the matter in dispute is considered to lie with whichever party proves itself the stronger in this contest. The game is peculiar to the swamp Warraus, who live in the swamps of the mouths of the Orinoco, and live here chiefly on the aeta palm, not cultivating any food-stuff, but eating the fruit of this palm and the pith of its stem, not making any fermented drink, as other Redmen do, but drinking only water and the sap of this same palm, building their houses, not as Humboldt thought, actually *in* these palms, but yet entirely, floor, posts, and roof, *of* the various parts of this palm. The physical features of the north-western district are like, yet in some respects different from, those of the rest of the colony. The watershed from which the main rivers, the Waini, Barama, Barima, and the Amakuru, run down to the sea, is here nearer to the coast-line than it is further south. Two more important consequences arise from this. The bare dry savannah of the interior of other parts of the colony is here unrepresented, the whole district being practically within the forest belt. And the rivers are both shorter and deeper, though their mouths are very wide. Moreover, these rivers are curiously connected both by a remarkably elaborate network, probably hardly paralleled in any other part of the world, of natural and semi-natural water channels—such as those described—and by an almost equally elaborate network of Redmen's paths through the forest.

The inhabitants of this district were, ten years ago, Redmen, and Redmen only. Their distribution is interesting when taken in connection with the distribution of their kind throughout the colony. The Redmen of Guiana consist of many small tribes, the best known of which are the Arawacks and the so-called Caribs—true Caribs they are preferably called. These two last-named tribes owe the fact that they are the best known to the circumstance that they shared between them the West Indian Islands south of Jamaica at the time of their discovery by Columbus; and they are the last remnants of those people who were the victims of that brutal policy of extermination by cruelty followed by the Spanish conquerors of the New World. The north-western district is some 9500 square miles in extent, and rises gradually from the sea to the range of somewhat higher land, which is represented, with some exaggeration, on most existing maps as the Sierra Imataca range of mountains, but which, within the limits of British Guiana, never attains a general level of more than 300 or 400 feet. The lower or alluvial part of this country consists of some of the richest soil in the world. Parts which have since been taken in and drained now yield crops of tropical produce of simply amazing abundance. As an illustration, a garden which hardly two and a half years ago was cleared and drained already has in it avenues of trees (*Casuarina*) of over 40 feet high, which were then planted. On the other hand, the higher part of the new district is being fast overrun by very successful gold-diggers.

For geographical reasons the most convenient centre from which to administer the district was at the point at which the Morawhanna leaves the Barima. This is near the centre of the waterway which traverses the northern part of the colony from the sugar fields about the mouth of the Essequibo to its northern limits on the Orinoco, by which, in the absence of roads, all traffic from the Orinoco to the older established parts of the colony must necessarily pass. Here, therefore, the central station, with the Government Agency, the police barracks, the hospital, and the other buildings, public and private, which go to make up the chief township, have been placed, and are fast being added to. A large station, with the other necessary accommodation, was also placed at the northern end of the waterway, on the mouth of the Amakuru; and other stations have been placed at intervals along the whole line.

SCIENTIFIC SERIALS.

THE *American Meteorological Journal* for May contains a paper read by Prof. W. M. Davis, before the New England Meteorological Society, entitled "Meteorology in the Schools." It points out the best plan to be adopted by a teacher to give his pupils a sound knowledge of the subject, and it will be found full of interest for many who may have made considerable progress in the study of meteorology. The complete solution of weather changes is far beyond the meteorology of the day, but the paper will teach the student to recognize the great difficulties attendant upon successful weather-predictions, and to discriminate between these and the predictions of those who pretend to outline the course of meteorological events for months ahead.—Thunderstorms in New England during the year 1886, by R. De C. Ward. The observation of thunderstorms was taken as a special subject of investigation by the New England Meteorological Society in the years 1885–87, and this paper is a preliminary report on the investigation, to be eventually published by the Harvard College. The storms were most frequent between May and August, and between 5h. and 7h. p.m. The average rate of movement throughout the year was 35 miles an hour. The influence of the tides on the direction of the storms is said to be brought out in several reports.—The storm of March 1–4, 1892, by J. Warren Smith. This storm was so severe in the New England States, and the snowfall and drift so heavy, as to cause in many places the cessation of all outside business; trains were blocked, and much damage done to shipping from the violence of the wind.

THE *American Meteorological Journal* for June contains the following original articles:—Flood-stage river predictions, by Prof. T. Russell. The paper gives some account of the methods by which the rules for river-stage predictions are derived. A river-stage is the vertical height of the water surface above the plane of low water, observed with a gauge. There are about 150 gauge stations maintained at various points in the United States. The predictions are mainly based upon observation of the stages and rises at certain points of a stream, and upon a consideration of what has occurred in previous cases, from which data factors are calculated. As a rule, rainfall observations are of little use in such predictions.—The first scientific balloon voyage, translated by R. De C. Ward, from an article by Dr. Hellmann. (See NATURE, vol. xlv. p. 471.)—Snowstorms at Chicago, by A. B. Crane. The writer has tabulated the records relating to the subject from 1879-90, and has discussed them with reference to the meteorological conditions prior to the storm. The heaviest storms occurred in January, the average temperature being 21°·4. He found that before the storms the temperature nearly always rises, and that it rarely falls for twenty-four hours previously.—The eye of the storm, by S. M. Ballou. This name is given to the calm area in the centre of a cyclone, where clear sky is generally visible. The author quotes accounts by various observers, and a review of the different explanations of the phenomenon.—Shall we erect lightning-rods?, by A. McAdie. The question being whether it is cheaper to insure buildings than to incur the expense of erecting lightning-rods, the author quotes a number of authorities in support of the advisability of putting up rods, and gives rules to be observed in doing so.

Bulletin of the New York Mathematical Society, vol. i., Nos. 8 and 9 (New York, 1892).—The illustrious German mathematician, Leopold Kronecker, died recently at Berlin (December 29, 1891). No. 8 (pp. 173-84) opens with a most interesting article, by H. B. Fine, entitled "Kronecker and his Arithmetical Theory of the Algebraic Equation." This is biographical and analytical. A short no e, by Prof. Cajori, follows, on the "Multiplication of Series." The concluding note is by Dr. Macfarlane, "On Exact Analysis as the Basis of Language." This is a brief abstract of a paper read before the Society (March 5, 1892).—No. 9 gives an account of a recent paper in the *Mathematische Annalen* (vol. xxxviii.), by M. Hilbert, under the head "Topology of Algebraic Curves." The writer, L. S. Hulburt, recasts the theory, with the view of making the theory more intelligible, and corrects some slight inaccuracies. Dr. Merriman abstracts a paper (read before the Society) on "Final Formulas for the Algebraic Solution of Quartic Equations." This number closes with a full account of Poincaré's "Mécanique Céleste," by E. W. Brown. The usual short notes and list of new publications are given at the end of each number.

Memoirs of the Mathematical Section of the Odessa University, vol. xiii.—On the theory of linear differential equations, by M. Rudzky.—The mechanics of a system subject to similar changes, by D. Seiliger, part iii. The paper is followed by a description of an apparatus, the "homoyograph," three spots of which always take such positions as to make similar triangles.—Experimental researches into the compressibility of glass and mercury, by G. De-Metz. The absolute compressibility of mercury has been determined on the two methods of Regnault and Jamin, as also on a third method which results from the equations of Lamé in his "Leçons sur l Élasticité," and the seventh memoir of Regnault. The results arrived at in these very elaborate researches are very near to those arrived at by Amagat.—Volume xii. of the same periodical consists of a work by J. Timtchenko, on the foundations of the theory of analytical functions. The aim of the author is to contribute towards the elaboration of a *general* theory of functions which would include Weierstrass's theory as well. The first part, now published, contains the historical review of the development of the theory.

Bulletin de la Société des Naturalistes de Moscou, 1891, Nos. 2 and 3.—The Speeton clays and their equivalents, by A. Pavloff and G. W. Lamplugh.—Contributions to the study of molecular forces in chemically simple bodies, on the ground of thermodynamics, by J. Weinberg.—Studies on the development of Amphipodes, part v., by Madame Catherine Wagner (in French, with two plates). The development of the embryo of the *Melita palmata* is apparently quite similar to that of *Gammarus* and *Caprella* in its earlier stages, but the microscopic observation of cuttings through the embryo discloses several interesting peculiarities, which are described and illustrated.—What is the Hipparion?, by Marie Pavloff (in French), being an answer to critical remarks, by M. Trouessart, in *Annuaire Géologique Universel*, tome vi., relative to Marie Pavloff's work on the evolution of Ungulates.—On a new apparatus for determining the moment of inertia of a body, by N. Joukovsky (in French).—On *Pteromonas alata*, Cohn, by M. Golenkin (in German).—The present state of our knowledge of the contents of the cells of the Phycochromaceæ, by Valerian Deinega (in German). The author has come to no definite results as to the nucleus in the Phycochromaceæ, especially in the thread-like species; new colouring methods ought to be discovered.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 2.—"Supplementary Report on Explorations of Erect Trees containing Animal Remains in the Coal-formation of Nova Scotia." By Sir J. William Dawson, F.R.S.

To the memoir which I had the honour to present to the Royal Society on this subject in 1882 [1] I appended a note from Dr. Scudder, of Cambridge, U.S., so well known for his researches in fossil Insects and Arachnidans, in which he gave a preliminary account of the remains of Arthropods in my collections which I had submitted to him. He has only in the present year completed his examination of these remains, most of which are very fragmentary, and much damaged by unequal pressure. The result has been embodied in a Report on Canadian Fossil Insects, now in course of publication by the Geological Survey of Canada.

In this Report he will describe from the contents of the Sigillarian stumps extracted by me, with the aid of the grant of this Society, three new species of Myriapoda, making, with the five previously known from these remarkable repositories, eight in all, belonging to two families, Archiulidæ and Euphoberidæ, and to three genera, *Archiulus*, *Xylobius*, and *Amynilyspes*. The three new species are *Archiulus euphoberioides*, Sc., *A. Lyelli*, Sc., and *Amynilyspes* (sp.). The remains of Scorpions he refers to three species, *Mazonia acadica*, Sc., *Mazonia* (sp.), and a third represented only by small fragments. The characters of the species referred to *Mazonia* he considers as tending to establish the generic distinctness of *Mazonia* from *Eoscorpius*. Dr. Scudder also notices the fragment of an insect's head containing part of a facetted eye, mentioned in my memoir, and considers it probably a portion of a Cockroach.

Much credit is due to Dr. Scudder for the care and skill with which he has worked up the mostly small and obscure fragments which I was able to submit to him, and which are probably little more than *débris* of the food of the Amphibians living for a time in these hollow stumps, and devouring such smaller animals as were so unfortunate as to be imprisoned with them. In this connection the suggestion of Dr. Scudder is worthy of attention, that the scaly armour of the smaller Microsaurians may have been intended to defend them against the active and venomous Scorpions which were their contemporaries, and some of which were sufficiently large to be formidable antagonists to the smaller land Vertebrates of the period.

The report of Dr. Scudder will complete the account of the land animals of the erect Sigillariæ of the South Joggins, unless by new falls of the cliff fresh trees should be exposed. From 1851, when the first remains were obtained from these singular repositories by the late Sir Charles Lyell and the writer, up to the present time, they have afforded the remains of twelve species of Amphibians, three land Snails, eight Millipedes, three Scorpions, and an Insect.

The type specimens of these animals have been placed in the Peter Redpath Museum of McGill University, and such duplicates as are available will be sent to the British Museum and that of the Geological Survey of Canada.

June 16.—"On the Estimation of Uric Acid in Urine." By F. Gowland Hopkins.

The process described depends upon the complete insolubility of ammonium urate in saturated solutions of ammonium chloride.

The pure chloride is powdered, and added to the sample to complete saturation. After two hours' standing, the whole of the uric acid separates as biurate of ammonium. The urate is then decomposed with hydrochloric acid, and the liberated uric acid determined by any approved method. In contrast to the well-known Fokker-Salkowski process the separation is rapid and complete.

The author has experimented with permanganate solutions for the titration of the separated uric acid, and finds that accurate results may be obtained by their employment. For this purpose the uric acid is dissolved in 100 cc. of water, with a minimum of Na_2CO_3, 20 cc. of strong H_2SO_4 being then added, and the solution immediately titrated with one-twentieth normal permanganate of potassium. The addition of 20 per cent. H_2SO_4 to the previously cooled solution of sodium urate yields just such a temperature (about 60°C.) as is requisite for a determinate reaction. 1 cc. of the permanganate solution is equal to 0·00375 grm. uric acid.

Physical Society, June 24.—Prof. A. W. Rücker, F.R.S., in the chair.—The following communications were made:—On breath figures, by Mr. W. B. Croft. After mentioning the observations of early experimenters on the subject, the author described a method which he found to give the best results. A coin is placed on a glass plate for insulation; another glass plate, which is to receive the impression, is well polished and laid on

[1] Phil. Trans., 1882, p. 621.

the coin, whilst a second coin is placed above the first. The coins are put in connection with the poles of an electrical machine, giving one-inch sparks for two minutes. When the coins are removed and the glass breathed on, clear frosted pictures of the coins are seen on the glass. The microscope shows that moisture is deposited on the whole surface, the size of the minute water granulation increasing as the part of the picture is darker in shade. The thickness of the glass seemed to make no difference to the result, and several plates and coins might be piled up alternately. If carefully protected, time appears to have little effect on the figures, but they can be removed by rubbing whilst the glass is moist. Failures and their causes were discussed, and the more complex phenomena produced by strong discharges described. It was also pointed out that breath figures could be produced by laying a coin on a freshly split surface of mica, and that a coin laid on glass for some time leaves its traces. Perfect reproductions of printed matter have been obtained by placing a paper printed on one side only between two sheets of glass for ten hours. Some substances, such as silk in contact with glass, give white figures; whilst wool, cotton, &c., give black ones. Various analogous effects are noticed in the paper, and the several views put forward in explanation of the phenomena examined.—A communication on the same subject, from the Rev. F. J. Smith, was read by Prof. Perry. He had investigated some of the effects, and succeeded in photographing the impressions, prints from which were shown. He had also examined the influence of various gases on the results, and found that oxygen gave the best figures. In a vacuum no figures could be obtained. The effect of temperature had also been tested. Prof. S. P. Thompson said details of early researches were given in *Poggendorff's Annalen* for 1842. It was there pointed out that better results were obtained by putting a spark gap between the coin and the machine. Since the effects did not depend on the way in which the sparks passed, he thought it was probable that electrical oscillations were involved. He himself had worked at the subject in 1881, and recently repeated some of the experiments. Figures could be produced on almost any polished surface; he got the best results by using a small induction coil giving 3 mm. spark, for about five seconds. In 1881 he accidentally noticed that photographs could be got on ebonite. Hot coins put on uncleaned glass gave good breath figures. A member said that instead of breathing on the plates, he and Mr. Garrett had sifted finely powdered red lead on them, to get the figures. They had also fixed the figures by etching with hydrofluoric acid. Mr. Croft exhibited some figures he obtained two years ago, which were still quite distinct.—On the measurement of the internal resistance of cells, by Mr. E. Wythe Smith. After referring to the methods hitherto used, the author described a modification of Mance's test which he had recently devised. One pole of the battery to be tested is connected to the similar poles of two other batteries; each battery has a separate circuit, through which currents are allowed to pass. Selecting a point A at the opposite pole of the battery to be tested, points B and C in the circuits of the auxiliary batteries are found, whose potentials are equal to that of A. The resistances between each pair of points AB, AC, BC, are then measured by a Wheatstone's bridge. Calling these resistances R_1, R_2, and R_3 respectively, it is shown that the internal resistance required is given by the formula $b = x + \frac{x^2}{r} + \frac{x^3}{r^2} + \&c.$, where $x = \frac{R_1 + R_2 - R_3}{2}$, and r is the external resistance of the circuit containing the battery tested. For an accumulator discharging, $b = x$ to within about 2 per cent. Prof. Perry inquired how far the results obtained agreed with those got by the older methods, and whether they depended on the time the keys were kept down. In the old methods it was assumed that an instantaneous rise in P.D. occurred on breaking the circuit. This might or might not be true. He was inclined to regard the P.D. and current as functions, both of resistance and time. The behaviour of cells seemed to indicate the existence of something like capacity, or rather, capacities and resistances in series. Prof. Ayrton said the paper was of great interest, for it made possible what could not be done before, viz. to find the resistance of a cell without appreciably altering the current through it. Although the new method required more cells, this was not prohibitive, for the result sought was of considerable scientific importance. The same method was applicable for finding the resistance of dynamo-armatures when working, a quantity which had hitherto been unattainable by direct measurement. Mr. Lane Fox said the perplexing changes in the P.D. of secondary cells were to be accounted for by changes in the electrolyte, which occurred in the pores of the plates. He could detect no flaw in the reasoning given in the paper. Dr. Sumpner remarked that the method was a valuable one, for it depended on bridge tests which could be made with considerable accuracy. On the other hand, it was a false zero method, and therefore liable to errors arising from changes of this zero. Prof. Ayrton pointed out that these errors could be eliminated by reversing the bridge battery. Mr. Rimington said although the testing currents were small they might affect the E.M.F., and thus introduce an error in b. This might be tested by using alternate currents and a telephone. In reply to Prof. Perry, Mr. Smith said the results agreed with those obtained by the older methods to within the limits of accuracy obtainable by the latter methods; this might amount to something like 15 per cent.—On the relation of the dimensions of physical quantities to directions in space, by Mr. W. Williams. In February 1889, Prof. Rücker recalled attention to the fact that, in the ordinary dimensional formulæ for electrical quantities, the dimensions of μ (permeability) and k (specific inductive capacity) are suppressed. In the discussion on that paper Prof. S. P. Thompson pointed out that lengths should be considered as having direction as well as magnitude, for, if so regarded, difficulties arising from different units, such as *couple* and *work*, having the same dimensions, would be avoided. Developing this idea, the author takes three mutually perpendicular lines, along which lengths are measured. Calling unit lengths along these lines X, Y, and Z respectively, the various dynamical units, such as velocity, acceleration, force, work, &c., are expressed in terms of M, T, X, Y, and Z. The formulæ then denote the directional as well as the numerical relations between the units, and the dimensional formulæ are therefore regarded as the symbolical expressions of the physical nature of the quantities, so far as they depend on lengths, mass, and time. In this system areas and volumes are represented by products of different vector lengths instead of by powers of a single length, and angles and angular displacements by quotients of rectangular vectors, instead of being pure numbers. For physical purposes pure numbers may be defined as ratios of concretes of the same kind similarly directed (if directed at all). A plane angle has dimensions $X^{-1}Y$, X being in the direction of the radius, and Y that of the arc, whilst solid angles have dimensions YZX^{-2}, and radii of curvature Y^2X^{-1}. It is also shown that π is a concrete quantity of the dimensions either of plane or of solid angle. This is of considerable importance in connection with the radial and circuital fluxes in the electromagnetic field. In deducing the dimensional formulæ for electrical and magnetic units, the rational and simplified relations given by Mr. Oliver Heaviside in the *Electrician* of October 16 and 30, 1891, are used. Instantaneous axes are taken at any point of an isotropic medium (the ether) such that X coincides with the electrical displacements, Y with that of the magnetic displacement, and Z with the intersection of the two equipotential surfaces at that point. Starting with the relation μH = energy per unit volume, the formulæ for the various quantities in terms of μ are obtained. These simplify down to those of the ordinary electro-magnetic system by putting $\mu = 1$ and suppressing the distinction between X, Y, and Z. Similarly, commencing with kE^2 = energy per unit volume, formulæ in terms of k are obtained, which, when simplified as above, give those of the ordinary electrostatic system. Examples of the consistent way in which the results work out are given in the paper, and the whole subject is discussed in detail, both by Cartesian and vectorial methods. The formulæ in terms of μ and k are used to trace out and examine the various analogies between electro-magnetism and dynamics, thereby obtaining a connected dynamical theory of electromagnetism. Inquiry is then made as to what dimensions of μ and k in terms of M, T, X, Y, Z, render the interpretation of electrical and magnetic units simple, natural, and intelligible as a whole. The conditions imposed (for reasons stated in the paper) are, first, that the dimensions of μ and k satisfy the relation $[\mu k] = Z^2T^{-2}$; second, that the powers of the fundamental units in the dimensional formulæ shall not be higher or lower than those found in the formulæ of the ordinary dynamical quantities; and, third, that quantities which are scalar or directed must also be scalar or directed when their dimensions are expressed absolutely. Subject to these conditions, it is shown that the possible dimensional values of μ and k are eight in number. Of these only two lead to intelligible results. These are—

$$(1)\ \mu = M(XYZ)^{-1} \text{ and } k = M^{-1}XYZ^{-1}T^2.$$

and

$$(2)\ \mu = M^{-1}XYZ^{-1}T^2 \text{ and } k = M(XYZ)^{-1}.$$

According to (1), μ is the density of the medium, electrical energy is potential, and magnetic energy kinetic. By (2), k is the density of the medium, electrical energy is kinetic, and magnetic energy potential. Full interpretations of the dimensional formulæ of all the electro-magnetic quantities, as obtained in accordance with the above conditions, are given in the paper. Prof. S. P. Thompson said the paper was a very important one, and thought the idea of finding dimensions for μ and k which would rationalize the ordinary dimensional formulæ a great step. The use of vectors was a valuable feature, whilst the employment of X, Y, and Z instead of L removed many difficulties connected with dimensional formulæ. Other difficulties might be cleared up by paying attention to the signs of the vector products and quotients, and to the order in which the symbols were written. Another important matter was the use of Mr. Heaviside's "rational units," a system which merited serious attention. In conclusion, Prof. Thompson expressed a hope that, in accordance with the resolution of the Electrical Congress at Frankfort, both permeability and specific inductive capacity should be designated by Greek symbols. Prof. O. Henrici expressed his admiration of the way in which the subject had been treated in the paper. He had long held that clear ideas of physical quantities were best got by vectorial methods. He also congratulated the author on his treatment of plane and solid angles as concrete quantities. In a communication addressed to the Secretaries, Prof. O. J. Lodge remarked that physicists in England were more or less familiar with the advantages of retaining μ and k in dimensional expressions before Prof. Rücker's paper of February 1889 brought the matter closely home to students. The system of mechanical dimensions suggested for electrical quantities in an Appendix to "Modern Views of Electricity" was not put forth as the only one possible, but as one having certain probabilities of truth in its favour. Prof. Rücker said that, although Mr. Williams and himself had talked over certain minor points in the paper, the main ideas brought forward were quite original, having been fully developed by Mr. Williams before he mentioned the subject to him (Prof. Rücker).—A paper on molecular forces, by Mr. W. Sutherland, communicated by Prof. Carey Foster, was taken as read. The Chairman announced that both this paper and that of Mr. Williams would be printed in the *Philosophical Magazine* during the long vacation, so that they could be fully discussed early next session.

Linnean Society, June 16.—Prof. Stewart, President, in the chair.—Mr. F. Enock exhibited some specimens of the Mustard Beetle, and gave an account of its recent depredations as observed by himself. So numerous was it that in walking down a single row of mustard, a distance of sixty-five yards, he had captured with a butterfly net upwards of 15,000, as he subsequently ascertained by counting a portion and weighing the remainder. The crop of mustard thus affected he regarded as destroyed.—Mr. R. I. Pocock exhibited and made some remarks upon a species of Peripatus (*P. juliformis*) from St. Vincent, of which five specimens had been collected by Mr. H. H. Smith for the Committee investigating the fauna and flora of the Lesser Antilles. The species was originally described so long ago as 1826, by the Rev. L. Guilding (*Zoological Journal*, vol. ii.), but from that time until the present no additional specimens had been procured there. As Guilding's types had been lost, and his descriptions are wanting in detail, this rediscovery was of considerable interest.—Mr. George Murray exhibited and described the type of a new order of Algæ, to which the name *Splachnidium rugosum* was given.—A paper was read by Prof. J. R. Henderson, entitled "Contributions to Indian Carcinology," and embodied an account of several little-known Crustaceans, and descriptions of some new species.—Mr. H. B. Guppy read a paper on "The Thames as an Agent in Plant Dispersal," in which several interesting facts were brought out, the observations being illustrated by specimens collected by the author, and a useful record given of the effects of exposure to sea-water, and of freezing, upon the germinating power of seeds.—Prof. F. Oliver gave an abstract of observations made by Miss M. F. Ewart, on some abnormal developments of the flowers of *Cypripedium*, illustrated by effective diagrams in coloured chalk.—Mr. R. I. Pocock contributed some "Supplementary Notes on the Fauna of the Mergui Archipelago," the result of his examination of some fresh material which had lately come to hand.—The evening was brought to a close by an exhibition by Mr. Carruthers, with the aid of the oxy-hydrogen lantern, of some beautiful slides of sections of fossil plants. A second series, zoological, exhibited by the President, included several minute organisms of extreme interest.—This meeting brought the session of 1891–92 to a close.

Anthropological Institute, June 21.—Edward B. Tylor, F.R.S., President, in the chair.—Dr. R. Wallaschek read a paper entitled "An Ethnological Inquiry into the Basis of our Musical System." In the course of the paper he pointed out that harmony is not a modern European invention, but known to many savage tribes, and even to the Hottentots and Bushmen. A regular bass accompaniment (to distinguish it from songs in harmonious intervals) is far more seldom to be met with, as the extreme simplicity of primitive songs does not admit of much variety in accompaniment. On the other hand, some savage tribes (Hottentots, Malays, Negroes) show an astonishingly great talent in accompanying European tunes by ear. Both keys, the major as well as the minor, occur in the songs of primitive races. Minor chords also occur occasionally. There is no internal connection between a peculiar key and a peculiar mood or disposition of mind. The diatonic scale does not seem to be a more recent invention than the pentatonic. The most ancient diatonic division is to be met with in instruments (pipes, flutes) of the Stone period. This early occurrence seems to be due to the fact that the diatonic scale is the most natural for the player's fingers, while it is at the same time the most effective. The diatonic system is neither an "artistic invention," nor a "scientific discovery," nor is it "natural" for the voice or the ear, nor based upon the laws and conditions of sounds, but it is the most natural for the hand, and the most practical for playing instruments.—Prof. Basil Hall Chamberlain then read a paper on 'some minor Japanese religious practices. After mentioning various miscellaneous usages and superstitions, the author treated chiefly of Japanese pilgrims and their ways, illustrating his remarks by an exhibition of a large collection of charms, sacred pictures, pilgrims' dresses, &c., brought together partly by himself, partly by Mr. Lafcadio Hearn. The collection included articles from the Shinto shrines of Ise and Izumo, from the "Thirty-three Holy Places" of Central Japan, from the "Eighty-eight Holy Places" of the island of Shikoku, from the temple of Asakusa in Tokyo, &c. The most curious was a sacred fire-drill from the great Shinto shrine of Izumo. This, together with a few of the other articles, has been presented by Prof. Chamberlain to the Pitt-Rivers Museum at Oxford. Another feature of the paper was the translation given of a Buddhist legend explaining the origin of the pilgrimage to the "Thirty-three Holy Places," and of some of the hymns intoned by the pilgrims.

Geological Society, June 22.—W. H. Hudleston, F.R.S., President, in the chair.—The following communications were read:—Contribution to a knowledge of the Saurischia of Europe and Africa, by Prof. H. G. Seeley, F.R.S. The Saurischia are defined as terrestial unguiculate Ornithomorpha, with pubic bones directed downward, inward, and forward to meet in a ventral union. The forms of the pelvic bones vary with the length of the limbs, the acetabulum becoming perforate, the ilium more extended, the pubis and ischium more slender, and the sacrum narrower as the limb-bones elongate. The order is regarded as including the Cetiosauria, Megalosauria, and Aristosuchia or Compsognatha. The Cetiosaurian pelvis has been figured in the *Quart. Journ. Geol. Soc.*; and a restoration is now given of the pelvis in *Megalosaurus*, *Streptospondylus*, and *Compsognathus*. The characters of the skull are evidenced by description of the hinder part of the skull in *Megalosaurus* found at Kirklington, and preserved in the Oxford University Museum. In form and proportions it closely resembles *Ceratosaurus*, and the corresponding region of the head in Jurassic Ornithosauria. The brain-cavity and cranial nerves are described, and contrasted with those of *Ceratosaurus*. The skull in Cetiosauria, known from the American type *Diplodocus*, is identified in the European genus *Belodon*, which is regarded as a primitive Cetiosaurian. Part 2 discusses the pelvis of *Belodon*, restored from specimens in the British Museum, and regarded as Cetiosaurian. A restoration of the shoulder-girdle is made, and found to resemble that in Ichthyosaurs, Anomodonts, and Dinosauria. The vertebræ in form and articulation of the ribs are Saurischian, the capitular and tubercular facets being vertical in the dorsal region, and not horizontal as in Crocodiles. The humerus shows some characters in common with that of *Stereorachis dominans*, in the epicondylar groove. In general character the limb-bones are more crocodilian than the axial skeleton. The interc'avicle is described and regarded as a family characteristic of the Belodontidæ. In the third part an account is given of *Staganolepis*, which is regarded as showing a similar relation with the Megalosauria, to that of *Belodon* with the Cetiosauria. This interpretation is based chiefly upon the identification of the pubic bone in *Staganolepis*, which has the proximal end notched as in *Zanclodon* and *Streptospondylus*; and the inner ridge at the proximal end is developed into an internal plate. A note follows on the pelvis of *Aëtosaurus*, which is also referred to the Saurischia on evidence of its pelvic characters, approximating to the Cetiosaurian sub-order. Part 4 treats of *Zanclodon*, which is regarded as closely allied to *Massospondylus*, *Euskelesaurus*, and *Streptospondylus*. It is founded chiefly on specimens in the Royal Museum at Stuttgart, and in the University Museum at Tübingen. The latter are regarded as possibly referable to *Teratosaurus*, but are mentioned as *Zanclodon Quenstedti*. The pelvis is described and restored. *Zanclodon* has the cervical vertebræ relatively long, as compared with *Megalosaurus*, and small as compared with the dorsal vertebræ, which have the same Teleosauroid mode of union with the neural arch as is seen in *Streptospondylus* and *Massospondylus*. The sternum, of Pleininger, is the right and left pubic bones; but there is much the same difference in the proximal articular ends of those bones in the fossils at Stuttgart and Tübingen, as distinguishes corresponding parts of the pubes in *Megalosaurus* and *Streptospondylus*. The ilium is more like that of *Palæosaurus* and *Dimodosaurus*. The limb-bones and digits are most like those of *Dimodosaurus*, but the teeth resemble *Palæosaurus*, *Euskelesaurus*, *Megalosaurus*, and *Streptospondylus*. Part 5 discusses *Thecodontosaurus* and *Palæosaurus* upon evidence from the Dolomitic Conglomerate in the Bristol Museum. An attempt is made to separate the remains into those referable to *Thecodontosaurus* and those belonging to *Palæosaurus*. The latter is represented by dorsal and caudal vertebræ, a scapular arch, humerus, ulna (?), metacarpals, ilium, femur, tibia, fibula, metatarsals, and phalanges. These portions of the skeleton are described. There is throughout a strong resemblance to *Zanclodon* and other Triassic types. A new type of ilium, and the humerus originally figured, are referred to *Thecodontosaurus*. Part 6 gives an account of the South African genus *Massospondylus*. It is based partly upon the collection from Beaucherf, in the Museum of the Royal College of Surgeons, referred to *M. carinatus*; and partly upon a collection from the Telle River, obtained by Mr. Alfred Brown of Aliwal North, referred to *M. Browni*. The former is represented by cervical, dorsal, sacral, and caudal vertebræ; ilium, ischium, and pubis; femur, tibia; humerus, metatarsals, and phalanges. The latter is known from cervical, dorsal, and caudal vertebræ, femur, metatarsals, and bones of the digits. The affinities with *Zanclodon* are, in some parts of the skeleton, stronger than with *Euskelesaurus*. Part 7 gives an account of *Euskelesaurus Browni*, partly based upon materials obtained by Mr. Alfred Brown from Barnard's Spruit, Aliwal North, and partly on specimens collected by the author, with Dr. W. G. Atherstone, Mr. T. Bain, and Mr. Alfred Brown, at the Kraai River. The former series comprises the maxillary bone and teeth, vertebræ, pubis, femur, tibia and fibula, phalanges, chevron bone and rib. The latter includes a cervical vertebra and rib, and lower jaw. The teeth are stronger than those of *Teratosaurus*, or any known Megalosaurian. The anterior part of the head was compressed from side to side, and the head in size and form like *Megalosaurus*, so far as preserved. The pubis is twisted as in *Staganolepis* and *Massospondylus*, with a notch instead of a foramen at the proximal end, as in those genera; and it expands distally after the pattern of *Zanclodon*. The chevron bones are exceptionally long, and the tail appears to have been greatly elongated. The femur is intermediate between *Megalosaurus* and *Palæosaurus*, but most resembles *Zanclodon* and *Massospondylus*. The tibia in its proximal end resembles many Triassic genera; and in its distal end is well distinguished from *Massospondylus* by its mode of union with the astragalus. The claw-phalanges are convexly rounded, being wider than is usual in Megalosauroids. The lower jaw from the Kraai River gives the characters of the articular bone, and the articulation, as well as of the dentary region and teeth. The cervical vertebra is imperfect, but is remarkable for the shortness of the centrum, being shorter than in *Megalosaurus*. In Part 8 an account is given of *Hortalotarsus skirtopodus* from Barkly East, preserved in the Albany Museum. It is a Euskelesaurian, and exhibits the tibia and fibula, and tarsus. There is a separate ossification for the intermedium, which does not form an ascending process; and the astragalus is distinct from the calcaneum. The metatarsals are elongated, and the phalanges somewhat similar to those of *Dimodosaurus*. Part 9, in conclusion, briefly examines the relations of the Saurischian types with each other, and indicates ways in which they approximate towards the Ornithosauria. It is urged that the Ornithosauria are as closely related to the Saurischia as are the Aves to the Ornithischia; and that both divisions of the Saurischia approximate in *Staganolepis* and *Belodon*. Finally, a tabular statement is given of the distribution in space and time of the 25 Old World genera which are regarded as probably well established. Eight of these are referred to the Cetiosauria, thirteen to the Megalosauria, and four to the Aristosuchia or Compsognatha.—Mesosauria from South Africa, by Prof. H. G. Seeley, F.R.S.—On a new Reptile from Welte Vreden, *Eunotosaurus africanus* (Seeley), by Prof. H. G. Seeley, F.R.S. The President observed that there could be no question as to the great value of these papers, the first of which especially was the outcome of years of experience and study on the part of the author. It was only right to remark that the paper on Saurischia was received by the officers of the Society early in *April*. Since that date Prof. Marsh, in his notes on Triassic Dinosauria (which did not appear till *May* 24), had published, as regards *Zanclodon*, conclusions similar to those at which the author (Prof. Seeley) had already arrived. Mr. E. T. Newton also spoke. Prof. Seeley drew attention to a photograph of *Hortalotarsus*, a reproduction of a sketch made at Barkly East, before the original specimen had been destroyed in the process of blasting the rock.—The dioritic picrite of White Hause and Great Cockup, by J. Postlethwaite.—On the structure of the American Pteraspidian, *Palæaspis* (Claypole), with remarks on the family, by Prof. E. W. Claypole.—Contributions to the geology of the Wengen and St. Cassian strata in Southern Tyrol, by Maria M. Ogilvie, B.Sc. (Communicated by Prof. C. Lapworth, F.R.S.)—Notes on some new and little-known species of Carboniferous *Murchisonia*, by Miss Jane Donald. (Communicated by J. G. Goodchild.)—Notes from a geological survey in Nicaragua, by J. Crawford, State Geologist to the Nicaraguan Government (Communicated by Prof. J. Prestwich, F.R.S.)—Microzoa from the phosphatic chalk of Taplow, by F. Chapman. (Communicated by Prof. T. Rupert Jones, F.R.S.)—On the basalts and andesites of Devonshire, known as felspathic traps, by Bernard Hobson.—Notes on recent borings for salt and coal in the Tees salt-district, by Thomas Tate.

MELBOURNE.

Royal Society of Victoria, March 12.—Annual Meeting.—The following officers were elected for the year:—President: Prof. Kernot. Vice-Presidents: Messrs. E. J. White, H. K. Rusden. Hon. Treasurer: Mr. C. R. Blackett. Hon. Librarian: Dr. Dendy. Hon. Secretaries: Prof. Spencer, Mr. A. Sutherland.—The following paper was read:—Preliminary notice of Victorian earthworms: Part 2, the genus Perichæta, by Prof. Spencer. The author described 18 species collected in Victoria, of which 16 are new.

May 13.—The following papers were read:—On confocal quadrics of moments of inertia pertaining to all planes in space, and loci and envelopes of straight lines whose moments of inertia are of constant magnitude, by Martin Gardiner.—Further notes on the oviparity of the larger Victorian Peripatus, generally known as *P. leuckartii*, by Dr. Dendy. In this paper the author replied to some remarkable strictures recently passed upon his work by Mr. J. J. Fletcher in the Proceedings of the Sydney Linnean Society. He showed that at the time of writing his first paper on this subject nothing was known as to the method of reproduction of *P. leuckartii*, Mr. Fletcher's brief footnote to the effect that one specimen dissected was found to be pregnant not of necessity implying the presence of developed embryos within the egg-case. The Victorian specimens, containing in their uterus large eggs, might with equal truth be described as pregnant. Dr. Dendy brought forward evidence proving conclusively that in the eggs investigated by him development had gone on normally outside of the body for a period exceeding eight months, one of them at the close of this time containing a perfect young form with even the pigment developed. Since the publication of his first paper, but not prior to this, Mr. Fletcher had shown that the New South Wales *Peripatus leuckartii* was undoubtedly viviparous; and Dr. Dendy suggested that if, as seems most probable, the Victorian species is oviparous, then his original idea of its being a distinct species from the New South Wales form may probably be correct.

PARIS.

Academy of Sciences, June 27.—On the local disturbances produced underneath a heavy load uniformly distributed along a straight line perpendicular to the two edges, on the upper surface of a rectangular beam of indefinite length laid down on a horizontal surface, or on two transverse supports equidistant from the load, by M. J. Boussinesq.—Contribution to the study of the function of camphoric acid, by M. A. Haller.—On the presence and the nature of the phylacogenic substance in the ordinary liquid cultivations of *Bacillus anthracis*, by M. Arloing. The liquid was carefully siphoned off from a large cultivation of the bacillus which had been allowed to stand for a considerable time. The usual porcelain filters were not employed, as they are apt to intercept most of the prophylactic substances. A liquid perfectly free from the anthrax bacillus having thus been obtained, two solutions in glycerine were prepared, the one containing the substances soluble in alcohol, the other those precipitated by alcohol. Of six lambs, two received subcutaneous injections of the former, two of the latter solution, and the rest of neither. Eight days afterwards all six were inoculated with a very virulent dose of the bacillus. The only survivors were those inoculated with the matter soluble in alcohol, thus proving that the prophylactic substance belongs to this group.—On the determination of the angle of polarization of Venus, by M. J. J. Landerer. By almost daily observations, extending from April 29 to June 8, the angle of polarization of Venus was found to vary between 45°·17 and 27°·51, using an instrument of 135 mm. aperture, to which a Cornu photo-polarimeter was adapted. The author concludes that the light from the crescent of Venus is not polarized, and hence that almost the entire visible surface of the planet is constituted by a thick layer of clouds. At the poles, however, permanent spots are observable, which are due to part of the solid surface protruding beyond the cloudy mass.—On the variations in temperature of water suddenly compressed to 500 atmospheres between 0° and 10°, by M. Paul Galopin. An account of the first of a series of experiments to be made in M. Raoul Pictet's laboratory to determine the heat produced by the adiabatic compression of a large number of liquids between − 200° and + 200°, under sudden variations of pressure amounting to 1000 atmospheres. The apparatus consists of a steel cylinder provided with a thermometer 1 m. long, capable of measuring 0°·01. Pressure is applied by means of a Cailletet pump, and the whole apparatus is immersed in a large calorimeter with quadruple envelopes. The results obtained, which vary from 0°·20 at 0°·4 to 0°·59 at 10°, show that the increase of pressure lowers the temperature of maximum density of water for that particular pressure, and that under high pressures it corresponds nearly to the freezing-point.—Measurement of the dielectric constant by electro-magnetic oscillations, by M. A. Perot. This measurement is based on the law formulated by Blondlot, according to which the period of the resonators is proportional to the square root of their capacities. The value obtained for essence of terebenthine was 2·25, that for ice between 60 and 71, in confirmation of previous results.—On the conductivity of a gas inclosed between a cold metal and an incandescent body, by M. Edouard Branly.—On the physiological effects of alternating currents with sinusoidal variations: process of administering them in electro-therapeutics, by M. A. d'Arsonval. The law indicated by the results of the experiments is that the intensity of the motor or the sensory reaction is proportional to the variation of potential at the point excited. Although oscillations of great frequency seem to have but faint physiological effects, a careful analysis shows that the absorption of oxygen and the elimination of carbonic acid in the lungs is greatly augmented.—On aluminium, by M. Balland. A series of experiments to prove that aluminium is well-suited for domestic utensils, being not more attacked by air, water, wine, coffee, milk, butter, &c., than other metals used for such purposes.—Action of chlorine on the alcohols of the fatty series, by M. A. Brochet.—On asboline (pyrocatechine and homopyrocatechine), by MM. Béhal and Desvignes.—On the vegetable cholesterines, by M. Gérard.—Researches on the adulteration of the essence of sandalwood, by M. E. Mesnard.—On two specimens of the waters of the Arctic seas, by M. J. Thoulet.—New remarks on "pœcilogony," by M. Alfred Giard.—On a sporozoarian parasite of the muscles of the Decapod Crustaceans, by MM. F. Henneguy and P. Thélohan.—The first phases in the development of certain nematoid worms, by M. Léon Jammes.—A contribution to the history of ambergris, by M. S. Jourdain.—On the *brunissure*, a disease of the vine caused by the *Plasmodiophora Vitis*, by MM. P. Viala and C. Sauvageau.—On the secretion of oxygen in the natatory vessel of the fishes, by M. Chr. Bohr.—Physiological action of mountain climates, by M. Viault. The effects of a high elevation, though powerfully beneficent for dyspeptics, neurasthenics, and tuberculous patients, must be long continued to be permanent. The effects are due to an increase in the number of blood corpuscles and in the respiratory power of the blood.—Permanent abolition of the chromogenic function of the *Bacillus pyocyaneus*, by MM. Charrin and Phisalix.

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