THURSDAY, FEBRUARY 28, 1889.

THE ZOOLOGICAL RESULTS OF THE "CHALLENGER" EXPEDITION.

Report on the Scientific Results of the Voyage of H.M.S. "Challenger" during the Years 1873–76, *under the command of Captain George S. Nares, R.N., F.R.S., and the late Captain Frank T. Thomson, R.N.* Prepared under the superintendence of the late Sir C. Wyville Thomson, Knt., F.R.S., &c., Director of the Civilian Staff on board, and now of John Murray, LL.D., Ph.D., &c., one of the Naturalists of the Expedition. Zoology—Vol. XXVIII. Published by Order of Her Majesty's Government. (London: Printed for Her Majesty's Stationery Office, and sold by Eyre and Spottiswoode, 1888.)

THIS volume contains but one Report, that on the Siphonophoræ collected during the voyage of the *Challenger*, by Ernst Haeckel, M.D., Ph.D., &c. The manuscript was received in instalments between February 8 and July 5, 1888.

In the editorial note we read :—" Prof. Haeckel, through his long-continued and elaborate investigations of living Siphonophoræ and Medusæ in the Mediterranean, Indian and Atlantic Oceans, was in a very special manner fitted to undertake such a task as this Report ; and it must be regarded as fortunate that he should have been willing to undertake the work on condition that some of his own unpublished observations should be incorporated. This important and masterly Report has thus become a monograph of the whole class more complete than hitherto published ; the classification has been reformed and placed on a new basis. The introduction, giving a general account of the morphology of the order, was translated from the German manuscript by Mr. J. Arthur Thomson, M.A. All the remaining part of the Report was written by Prof. Haeckel in the English language."

It may be fearlessly asserted that no living biologist is more capable of writing a Report on the *Challenger* Siphonophoræ than Prof. Haeckel, and but little objection could be taken to the request that his previous original work should be incorporated with that more particularly devoted to the results of the *Challenger's* expedition ; nay, personally, we are inclined to think that a Report should benefit immensely by the incorporation of such work, the more especially in the case of a class like that of the Siphonophoræ, where the drawings from the life are of paramount importance.

It is well known to all interested in the beautiful and graceful forms which constitute the class of the Siphonophoræ, that Prof. Haeckel's " System der Siphonophoren, auf phylogenetischer Grundlage entworfen" appeared in the *Jenaische Zeitschrift* for May 1888 ; and in the present Report (p. 356) he himself tells us that a separate edition of this important paper was published in December 1887. The general introduction to the Report, which the editor informs us was translated from the German manuscript furnished between February and July 1888, is declared by Prof. Haeckel to be translated from the general part of the above-mentioned separate edition ; and, as a matter of fact, a reference to the *Jenaische Zeitschrift* shows this to be the case, with an addition of three pages on " the fundamental form (promorph)." This is but a small matter, but the statement in the preface is certainly one apt to mislead the reader, who ought to have been informed of the previous publication of the general introduction, without being left to stumble upon the statement of the fact on almost the last page of the volume.

Since the publication of the memoir on the Siphonophoræ in the *Jenaische Zeitschrift*, the classification of the group has been but little " reformed," and has certainly not been placed " on a new basis." In the " System " there are seventy-five genera enumerated, which are included in twenty-two families, divided into five orders. In the Report the orders remain the same, two of the subfamilies are elevated to the rank of families, and some half-dozen of the genera are subdivided. Their numerical arrangement is unaltered, but letters are added to the running numbers of the " System " ; thus Genus 75 in both the " System " and the Report is Physalia, Lamk., while in the Report the genus Caravella, Hkl., is added as 75*b*. There being no index of genera and species, this partly numerical and partly alphabetical systematic arrangement of the genera makes the volume difficult of reference.

That this Report, able as it is, cannot be regarded as a " monograph " of the order will be generally acknowledged when the following facts are considered. The first order, Disconectæ, contains three families ; the first of these, with a circular and regular octoradial umbrella, and with mouthless blastostyles, is called Discalidæ ; it contains two genera, Discalia and Disconalia. Of the former two species are named, both inhabitants of the deep sea, and both found by Haeckel in the *Challenger* collection ; the first species is described and beautifully figured as *D. medusina*, the second species, *D. primordialis*, n. sp., was captured in the tropical Pacific, at Station 274, and at a depth of 2750 fathoms ; but we read, p. 46, " as its state of preservation was not sufficient, I give only the description of the first well-preserved species." Of the genus Disconalia, " two species (both deep-sea inhabitants) were found by me in the *Challenger* collection, one from the Southern Pacific (Station 181), the other from the Indian Ocean, south of Australia (Station 157). The latter (*Disconalia pectyllis*) had much longer and less ramified tentacles, and a larger pneumatocyst, than the former (*Dis. gastroblasta*) ; but its state of preservation was not sufficient for a full description " (p. 48) ; nevertheless, we are promised that *Disconalia pectyllis* will be described afterwards in " my 'Morphologie der Siphonophoren' " (p. 357). These two instances occur within the margins of the first two dozen pages of the descriptive portion of the Report ; and when we call to mind the really wonderful way in which, from a few fragments, Prof. Haeckel has, in this very volume, diagnosed and even figured some of the *Challenger* species, we regret all the more that he has not here given us, at the very least, those descriptions which he has reserved for elsewhere. Among the list of *Challenger* species apparently good enough for future description, but though named yet not described in this Report, we note the following : *Eudoxella didyma*, Hkl. (Station 343, p. 108),—this genus is quoted from the " System " as Eudoxella, Hkl. ; but in the " System," we find it printed as Eudoxon, Hkl., which name would have priority«; *Anthemodes articulata*, Hkl., *Bathyphysa gigantea*, Hkl.

Numerous are the species named from living or preserved specimens, for the descriptions of which the readers of this "monograph" are referred to the forthcoming "Morphology," such as *Strobalia cupola*, Hkl. "This beautiful species was observed living by me in the Indian Ocean, and will be described in my 'Morphology of the Siphonophoræ'; a fragment of a similar species, *S. conifera*, was collected by the *Challenger* in the South Pacific (Station 288)" (p. 243); and again, "*Auralia profunda*, the single species of this genus which I have examined, was taken in the depths of the tropical Atlantic, and will be described in my 'Morphology,' &c." (p. 301).

We have probably quoted enough to show the very uneven treatment that has been meted out to the species of this class. Two hundred and forty of them are referred to by name, but only a small percentage of these are diagnosed; of those that are, some of them were found during the voyage of the *Challenger*, some of them were found by Prof. Haeckel during his own memorable and fruitful sojourns at Madeira and Ceylon, but for many of them we have nothing more than names. There is no doubt that to have made this Report a "monograph" a larger volume, perhaps another volume, would have been needed; but had it been kept within the limits of a Report on the *Challenger* species, it would not have occupied the space it at present does.

The volume contains 380 pages, and is illustrated by 50 plates, several of which are beautifully printed in colours. The plates were in some instances printed off before the text was printed; and of those coloured, all but one are after original coloured drawings of the author's. Amidst the number of strange, beautiful, and interesting forms described and figured, it is hard to make a selection; perhaps the greatest interest will be taken in the forms belonging to the new order of the Auronectæ. In this order there is present a peculiar and most remarkable organ, called the air-bell or aurophore: "it seems to be the modified umbrella of a medusome, and is adapted for the production and emission of the 'gas' contained in the large pneumatophore; the trunk of the siphosome is also thickened and bulbous, and traversed by a network of anastomosing canals, similar to the fleshy or cartilaginous cœnosome of the Alcyonidæ." There are two families, Stephalidæ and Rhodalidæ. The family Stephalidæ has two genera, Stephalia and Stephonalia. Of the former genus, the single species *S. corona* was found by Dr. Murray during the *Triton* Expedition, in the Faroe Channel; and of the second genus the single species *S. bathyphysa* was found by the *Challenger* in the South Pacific. The family Rhodalidæ also contains two genera, Auralia and Rhodalia. Of the first of these, *A. profunda*, as before mentioned, "the single species of this genus which I have examined was taken in the depths of the tropical Atlantic, and will be described afterwards in my 'Morphology of the Siphonophoræ.' Its external appearance is similar to that of *Stephalia corona*; but the nectophores of the simple corona are more numerous and the tentacles are of the same shape as in Rhodalia." As this is all we are told about the species, we cannot be certain whether it was a *Challenger* form or not. Rhodalia likewise has but one species, *R. miranda*. This wonderful form is described from specimens taken at Station 320, south-east of Buenos Ayres, and is figured on Plates 1-5.

Prof. Haeckel thinks that these Auronectæ are permanent deep-sea Siphonophoræ, which may move up and down within certain limits of depth, but never come to the surface. He regards their discovery as one of the most splendid made during the cruise of the *Challenger*; yet for a knowledge of what is known about them we must look beyond the pages of this Report.

A species of Anthophysa, taken at Station 334, has been called *A. darwinii*. Several other species are alluded to by name; it seems possible that Merten's manuscript name Anthophysa, published by Brandt, in 1835, is preoccupied by Bory de Saint Vincent for a genus of flagellate Infusoria.

In addition to the author's preface, and the general introduction, there is the usual description of the families, genera, and species, the deficiencies in which we have sufficiently alluded to. This is followed by a bibliography of the Siphonophoræ; a list of the families, genera, and species; a very useful glossary of the terms used in Latin, English, and German; and lastly, a statistical synopsis, from which we learn that 85 genera are enumerated, these containing 240 species. The diagnoses of 47 new species are given in this Report, of which 27 were found by the *Challenger*.

The characteristics of the orders and families are given in most satisfactory detail, and this portion of the Report would in itself constitute a most important and valuable general history of the group, and must serve for the ground-work of all future writings on the subject.

If too much has been claimed for this meritorious contribution to natural science from a monographical point of view, such a claim in no way takes from its merits as a profoundly important contribution to natural science.

THE ENCYCLOPÆDIC DICTIONARY.

The Encyclopædic Dictionary. Vol. VII., Part II. (London: Cassell and Co., 1888.)

ALL concerned in the production of this work may be congratulated on the completion of their undertaking. It is a work of more than ephemeral interest, and well deserves the favourable reception which has already been accorded to it. It was planned seventeen years ago, and the first divisional volume appeared in 1879. The intention at that time was that the Dictionary should consist of twelve divisional volumes, but, as the execution of the scheme went on, it became obvious that, unless the contents of the concluding volumes were to be presented in a very inadequate form, two additional divisional volumes would be necessary. It was arranged that these volumes should be supplied, and thus ample opportunity was provided for the maintenance, to the end, of a high standard of excellence.

The scale on which the work has been done may be seen from the fact that in round numbers it contains some 180,000 words or headings. This is a great advance on earlier dictionaries. The new edition of the Imperial Dictionary, which stands next, has 130,000 headings; the latest edition of Webster's Dictionary, with supplement, has 118,000; the early edition of Webster had

70,000; and Todd's edition of Johnson's Dictionary had 58,000. Even a general statement of the number of headings does not give an adequate impression of the amount of the contents of the present work, because, as pointed out in the preface, each word has been subdivided as far as possible into the various meanings which it has assumed at different times.

Judged simply as an ordinary dictionary, the work has high merits. No doubt, when Dr. Murray's vast undertaking is completed, both this and all other existing dictionaries will seem in many respects deficient; but for the present we do not know that anyone wishing to possess, for frequent reference, a sound, thoroughly trustworthy dictionary, could anywhere find his want more satisfactorily supplied than in these volumes. The question, what words can legitimately claim admission, had of course to be met at the outset, and it has been settled in a way that will commend itself to the judgment of all persons competent to form an opinion on the matter. All technical terms, so far as known, have been included; slang words, colloquialisms, and provincialisms have not been wholly omitted; specially coined words have also, in some instances, been recognized; and due respect has been shown to semi-naturalized words and to hybrid compounds. The department of etymology, we need hardly say, has received much careful attention; and great pains have been taken to provide quotations illustrative of every sense of each word, with references as full as could be given. The pronunciation of words is clearly indicated, and the adoption of various styles of type makes it easy for persons using the Dictionary to distinguish between various divisions and subdivisions of words.

As the title indicates, it is not merely as a dictionary that the work should be estimated. The aim has been to combine the advantages of a dictionary with those of an encyclopædia, and this idea has been realized with a remarkable degree of success. No one will expect to find here, under any heading, full information, such as one reasonably looks for in a great encyclopædia. Nothing of this kind has been attempted. But under each heading the thing is described as well as the word; and although the descriptions are necessarily brief, they are, so far as they go, clear and accurate, and no one who refers to them will afterwards have to unlearn anything they may have taught him. The short articles relating to the various branches of natural science are especially well done—a fact which will be readily understood when we say that the editor and publishers acknowledge the services of many eminent scientific workers, including Prof. Huxley, Dr. Sclater, Dr. Günther, and Mr. Carruthers.

OUR BOOK SHELF.

Manuel Pratique de Cristallographie. G. Wyrouboff. (Paris: Gauthier-Villars et Fils, 1889.)

MANY books have been written about crystallographic calculation, and their size and the uninviting appearance of their contents have probably created an impression that there is something peculiarly difficult in the subject. M. Wyrouboff's manual will not, we fear, dispel this erroneous idea, for about 300 of his pages are devoted to an exposition of the methods of calculation; but the book, being eminently practical, consists almost entirely of examples, which are fully worked out by simple and intelligible methods, while very little space is wasted upon the geometrical principles involved. The work is therefore very different in character from the geometrical treatises which have frequently adorned the subject, and will doubtless be of great use to the class for whom it is written—namely, "those to whom crystallography is only a means for the determination and description of species," to whom and to all who are attempting to acquire a practical knowledge of crystallography it may be warmly recommended. We would only suggest to such two words of caution: in the first place, the calculations are in each case conducted in two ways, by means of plane angles and solid geometry, and by means of spherical trigonometry,—the former method is unnecessary and undesirable; in the second place, the Millerian axes and notation of three indices should certainly be used in the rhombohedral system in preference to the notation of four axes.

M. Wyrouboff is so well known as the author of valuable contributions to the science of crystallography (by which we mean the knowledge of the relation between the physical, chemical, and geometrical characters of crystals as distinguished from either the study of mineralogy or the art of crystal-measurement), that the following remarks, taken from his preface, deserve particular attention:—

"How far more advanced would be our knowledge of the intimate structure of bodies if chemists were to describe accurately the form of the innumerable substances which issue from their laboratories, and which, being sometimes accidentally obtained, difficult to reproduce, or prone to rapid decomposition, are lost to science; and if, on the other hand, physicists were accustomed to connect the properties which they discover with the symmetry which belongs to the crystalline exterior. It is true that in doubtful cases, or such as are of particular interest, they both have willing recourse to the professional crystallographer; but, apart from the fact that he is not always at hand, experience teaches that such a division of labour rarely gives good results. Forms placed in arbitrary positions without regard to the forms of allied substances often serve only to conceal the analogies which are professedly sought," &c.

From which we gather that the position of crystallography in France is much the same as in England, and that such books as that of M. Wyrouboff, although not liable to be choked by the thorns of competition, are at present somewhat likely to fall upon the stony ground of indifference.

Assistant to the Board of Trade Examinations. By Captain D. Forbes, F.R.A.S. (London: Relfe Bros., 1888.)

IN preparing candidates for the Board of Trade examinations for officers' certificates, Captain Forbes has felt the want of a handy book of reference to the various questions asked, and he hopes to supply that want by the little book before us. In these examinations, the candidate has to show his knowledge by answering a number of a set of questions which is the same from year to year, although those selected by the examiner may be different. The questions put to the candidates, and the answers to them which the author suggests, are given in this little book. As examples of brevity, the definitions given of the various astronomical terms are unequalled in any book we are acquainted with. Thus, right ascension is defined as "the distance which a heavenly body is eastward of the first point of Aries"; while not the slightest idea is given of the meaning of the latter term. On p. 14, sidereal *time* is stated to begin when the first point of Aries is on the meridian, and to *end* when it returns to it again; how much information this will convey to a student we leave our readers to judge. The answers to the various questions which are asked on the sextant are far better than the definitions, as are also the answers to the questions on cyclones. The questions on the deviation of the compass, for masters' certificates, are also fairly well answered, although a little further explanation of Napier's diagram, which forms the frontispiece, might have been given with advantage.

For reference to the questions given, the book will no doubt be very useful to intending candidates, but the answers given are good examples of the system of cramming for examinations, which cannot be too strongly condemned.

Guatemala: The Land of the Quetzal. By William T. Brigham. (London: Fisher Unwin.)

MR. BRIGHAM, an American author, has made three journeys in Guatemala, and in the present volume he has brought together all that seemed to be important in the notes written during his travels. The work is one of great interest, and ought to be not less welcome to the general reader than to persons who have special reasons for studying the subject. Mr. Brigham is a keen observer, and records his impressions clearly, simply, and effectively. No one who, in imagination, attends him in his course across the continent to Coban, from Coban to Quezaltenango, from Quezaltenango to the Pacific, will fail to be attracted by what he has to say about the physical features of the country and about the manners of its inhabitants. There are also excellent chapters on Guatemala city, and on Esquipulas and Quirigua. A sufficiently full account is given of the vegetable and animal productions of Guatemala, and of its earthquakes and volcanoes. In an introductory chapter, Mr. Brigham has something to tell us about Central America generally, and it may be worth noting that these regions will one day, in his opinion, be "the garden and orchard of the United States, not necessarily by political annexation, but by commercial intercourse." Great care has been taken to secure the accuracy of the illustrations, most of which are direct reproductions from negatives.

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.*]

Weismann's Theory of Variation.

I THINK it may be reasonably objected to Mr. Cunningham's ingenious *reductio ad absurdum* of Weismann's theory, that because we cannot exactly state what happens in the mysterious fusion of sperm- and germ-nucleus, it by no means follows that such fusion does not largely account for the observed variation. I say largely, because Prof. Weismann's more recent paper, "Ueber die Zahl der Richtungskörper und über ihre Bedeutung für die Vererbung" (Jena, 1887), completes in a most important manner the paper quoted and criticized by Mr. Cunningham.

The argument is briefly as follows. The expulsion of the second polar body by sexual eggs is the removal of half the ancestral germ-plasms in order to make room for those which are added in fertilization. For this reason we must suppose that an equivalent reduction of the sperm-nucleus also takes place. If this reduction did not occur, the number of germ-plasms would be doubled in each sexually-produced generation —an unthinkable result.

If there were only one kind of germ-plasm in each nucleus, and sexual reproduction commenced, there would be 1024 distinct germ-plasms in each of them at the end of ten generations. But the number of generations must be so vastly in excess of ten that the number of ancestral germ-plasms in each sperm- and germ-nucleus must be considered to be infinite, or at any rate so large that the expelled halves would never be the same. It therefore follows that no two sperm- or germ-nuclei can be alike, and individual variation must follow. A little consideration also shows that while the children of the same parents must differ, they must also resemble each other more than the children of other parents, and while they must differ from their parents they must also resemble them more than the parents of other children.

The occurrence of atavism may be explained as a direct consequence of an unusual predominance of ancestral germ-plasms; the fact that atavism is a rare exception also follows from the fact that the expulsion of half the germ-plasms in each generation will nearly always prevent such predominance.

It is impossible to carry the subject further in the scope of a letter, or one might refer to the evidence for the absence of variability in parthenogenetic species, in which the second polar body is not expelled from the ovum; and to the identity of twins produced from a single ovum which has presumably divided after fertilization. E. B. POULTON.

Oxford.

A Correction.

WITH reference to my communication in last week's NATURE, Prof. Oliver Lodge has called our attention to the fact that we had made a mistake in stating that the wave-length of the vibration was 33 centimetres. It is the semi-wave-length that is 33 centimetres; the wave-length is 66 centimetres, as is evident on consideration of the size of the "vibrator."

FRED. T. TROUTON.

Temperature Observations in Rivers.

THE Committee appointed at the Bath meeting of the British Association to investigate seasonal variations of temperature in rivers and streams was able to arrange through local scientific Societies for thirty observers, commencing work in January 1889. Of these there are ten in England, ten in Scotland, and ten in Ireland. Each observer is supplied with a specially designed thermometer (costing 2*s.* 6*d.*) which has been compared with a standard instrument, and books for recording the observations and full instructions are provided by the Committee. It is desirable to extend the observations to rivers not yet taken up, and I therefore wish to direct the attention of local scientific Societies, of meteorological observers and others interested in similar work, to the opportunity now offered of taking part in a systematic investigation, the preliminary results of which show many interesting features. I shall be pleased to answer any inquiries of intending observers.

HUGH ROBERT MILL,
Secretary Brit. Assoc. Committee.

Heriot-Watt College, Edinburgh, February 20.

"Bishop's Ring."

IN your review of the Report of the Krakatão Committee of the Royal Society, it is stated that "Bishop's ring" has quite disappeared. Now this is hardly correct, for although I have not heard of anyone perceiving it in the middle of the day for a long time past, it is still visible about sunrise and sunset, though becoming on the whole gradually fainter. I presume that it is really the same phenomenon. At the time when "Bishop's ring" was most conspicuous in the full day-time, it was always far more so when the sun was rising and setting.

Sunderland, February 20. T. W. BACKHOUSE.

Peripatus in Australia.

Peripatus has been found not only in Queensland and Victoria, but also at Cassilis, in New South Wales, by Mr. A. S. Olliff, of Sydney. The Victorian and New South Wales localities are recorded in a postcript appended to my monograph of the genus as reprinted from vol. iv. of the "Studies from the Morphological Laboratory of the University of Cambridge." My knowledge of them is due to Mr. Olliff, who was kind enough to send me his specimen and his description of it (Proc. Linn. Soc. of

New South Wales, November 30, 1887). The New South Wales species is, I think, identical with that found in Queensland, and I should be inclined to doubt the distinctness of the Victorian species recorded by Mr. Dendy in NATURE (p. 366), and previously by Mr. Fletcher.

Mr. Dendy appears to lay some stress on the differences of colour as between his specimen and the specimens of *P. leuckarti* hitherto described, but it must be remembered that in some species of Peripatus—*e.g. capensis* and *novæ-zealandiæ*—the range of individual colour-variation is very considerable.

All the species that I have seen are very beautiful when alive; but the beauty, which is partly due to the texture of the skin, is very hard to reproduce in a drawing.

It is a remarkable fact that a creature which lives so entirely in the dark as does *Peripatus* should present such rich coloration and such complicated markings.

The egg of *Peripatus leuckarti* is heavily yolked and of a fair size, but smaller apparently than that of the New Zealand species. Its development cannot fail to be of the greatest interest, and it is sincerely to be hoped that the Australian zoologists will lose no time in working it out.

A. SEDGWICK.

Trinity College, Cambridge, February 18.

Anthelia.

I HAVE been following with much interest your notices of anthelia, and was about to add my mite to the information given, when, by the mail just in, I have your issue of October 25 last, wherein is a notice of the phenomenon as observed in Ceylon. I have witnessed it there scores and scores of times in my early tramps bird collecting, and I have also seen it at the Cape, in Brazil, on the Amazon, in Fiji, and in this island. On turning up my dear old friend Sir E. Tennant's book on Ceylon, I find that at p. 73, vol. i., he gives a very fair figure of the effect produced. It may be, as he says, that the Buddhists took from it the idea of a "halo" or "flame" for the head of Buddha, but there is one peculiarity about these flames that always struck me. In whatever position you find the Buddha, the flame is invariably in a straight line with the body even if the figure is recumbent. In form it always resembles the "tongues of fire" depicted by old painters as falling on the apostles on the Day of Pentecost.

I have seen many instances of what I suppose may be called "anthelia" in calm water, but the appearance is usually more *rayed*. I have an exquisite engraving in my print collection of the "Madonna and Dead Christ" by Aldegrever (1502–58). It has often occurred to me, in looking at it, that the artist has taken his idea of the halo round the Virgin's head from the appearance presented by the "anthelia" in water. There is the same luminous centre, and then the divergent rays. The halo round the head of the dead Christ in her lap is a four-cornered luminous star, issuing rays, of which three points only are visible—like nothing in nature with which I am acquainted.

E. L. LAYARD.

British Consulate, Noumea, January 3.

Mass and Inertia.

I AM pleased to see that Dr. Lodge has adopted my suggestion made in the *Engineer* about four years ago of using the term inertia for the quantity mass-acceleration. In making the suggestion I considered that I merely asked a return to the meaning implied by Newton in the phrase "*vis inertiæ*."

Unless this is the meaning of the term, the reason why Σmr^2 is called moment of inertia is almost incomprehensible. With it the connection is obvious; for, if ψ is the angular acceleration of a body about an axis, and r the distance of any particle, its linear acceleration is ψr, its inertia $m\psi r$. and its moment of inertia $rm\psi r$, or $m\psi r^2$. As the angular acceleration is the same for all particles of the body, the moment of inertia of the body is $\psi\Sigma mr^2$.

As Dr. Lodge mentions that he is bringing the matter before the British Association Committee on Units and Nomenclature, might I suggest that in future Σmr^2 should be called the *moment of inertia constant*, thereby implying the existence of the *variable factor* ψ, the angular acceleration, in the expression for moment of inertia.

E. LOUSLEY.

Royal College of Science, Dublin, February 16.

To find the Factors of any Proposed Number.

IT has long been a desideratum of mathematicians to discover a formula or method for ascertaining the factors of any proposed number, and also determining whether it be a prime or not. Their endeavours during the twenty centuries that have elapsed since Eratosthenes (B.C. 276–196) made the first recorded attempt to produce a practical rule for the purpose have not been attended with success.

As it may interest many readers of NATURE, and others, I propose, with a few preliminary remarks, to make known a simple arithmetical method by which this desideratum can now be attained.

Factors of an even number can readily be found, as 2 is always one of them, but it is not always so easy to find the factors of an odd number, especially if it be a high one, and, if the number be the product of two primes, the difficulty in this respect is still greater, because they are its only factors. Hitherto they could be ascertained only by trying in succession, as divisors, the prime numbers of less magnitude than its square root.

To find by such process the factors of 8616460799 (the square root of which is between 92824 and 92825), it might, possibly, be necessary to try 8967 prime numbers as divisors (out of the 8969 that there are) before they could be ascertained. By my process, division sums are altogether avoided. This high number occurs in a chapter on "Induction as an Inverse Operation," in "Principles of Science," by Stanley Jevons, second edition. His emphatic remarks as to the difficulties attending on inverse operations in general, and particularly those with reference to finding the factors of this number, were the incentive to my endeavouring to discover some process for ascertaining them which might possibly have escaped being previously tried. He states:—"The inverse process in mathematics is far more difficult than the direct process. . . . In an infinite majority of cases it surpasses the resources of mathematicians. . . . There are no infallible rules for its accomplishment. . . . It must be done by trial, . . . by guess-work. . . . This difficulty occurs in many scientific processes. . . . Can any reader say what two numbers multiplied together will produce 8616460799? I think it unlikely that anyone but myself will ever know. They are two prime numbers, and can only be discovered by trying in succession a long series of prime divisors, until the right one be fallen upon. The work would probably occupy a good computer many weeks. It occupied only a few minutes to multiply them together."

Mr. Jevons adds: "There is no direct process known for discovering whether any number be a prime or not, except by the process known as the 'sieve of Eratosthenes,' the results being registered in tables of prime numbers."

In the article on prime numbers in "Rees's Cyclopædia" (ed. 1819), the writer states: "It is in fact demonstrable that no such formula" (for discovering whether a number be a prime or not) "can be found, though some formulæ of this kind are remarkable for the number of primes included in them."

The difficulty of finding the factors of numbers is also referred to by the eminent writer (at that time President of the Mathematical Society)—under the initials C. W. M.—of an interesting review of "Glaisher's Factor Tables," in NATURE, vol. xxi. p. 462. In course of his remarks he mentions the number 3979769, and respecting it says: "It would require hundreds of division sums to ascertain by trial that it had 1979 for a divisor, and that consequently it was the product of 1979 × 2011;" and he adds, ". . . . there is no general mathematical principle which enables us to dispense with the trial, or even to shorten it, so as to bring it within practical limits."

These extracts afford conclusive evidence that no direct rule or method has hitherto been known, by which the factors of a number could be ascertained, and also that it is considered it would be a task of almost insuperable difficulty to devise one. Yet it seemed to me not unreasonable to think that, as two factors multiplied together formed a product, it ought to be possible to unmultiply or split up (as "C. W. M." expresses it) that product into its factors again, "without the enormous labour of trying for its divisors."

Strongly impressed with this idea, I attempted to realize it, and before long succeeded in discovering a simple arithmetical process for the purpose, and different from any previously tried. When applied to find the factors of 8616460799, instead of "many weeks being occupied" in the task, it showed, within a very reasonable time, that they were 96079 × 89681. When applied to find the factors of 3979769, instead of "hundreds of division sums" being requisite,—about two minutes of time, no division sum at all, only one of subtraction, showed them to be 2011 × 1979.

My method or rule consists in finding the next higher square (call it "A") to the proposed number, from which, if the proposed number be deducted, the difference, or remainder, will be a square number (call it "B"). Then the square root of A plus the square root of B will be one factor, and the square root of A minus the square root of B will be the other.

It is essential to state, in addition to this general rule, that, when the "difference" between the proposed number and the higher square first used (not necessarily the next higher square to it) is a square, the process is virtually ended, for the factors can then be readily found by the directions given above. But if "the difference" be not a square, successive additions must be made to it of a progressive series of numbers, whose common difference is 2, and commencing with twice the square root of the square first used, plus 1, until their sum becomes a square number, which will be that called B in the paragraph above.

This is simply an easier mode of ascertaining what the differences may be between the proposed number and the higher squares, than by subtracting one from the other at each step of the process. The aggregate sum of the additions, taken at any step, is always equal to the square of the square root corresponding to it, minus the proposed number. The square root corresponding to any step is always half the serial number then added, plus ½.

Hence my method may also be said to consist in the successive addition to the difference between any proposed number and a higher square, of a series of numbers as specified above, until their sum becomes a square.

The length of the process varies, and is longest when the difference between the factors of the proposed number is greatest, and especially if it be a high prime. But in many cases it can be shortened very considerably. It would require many examples to show how this can best be done under many varying circumstances. At present I give only a few examples to show the operation according to the general rule, and of one or two ways of shortening the work.

Examples.—Find factors of 1443, 57, 110467, 8616460799, and 3979769.

Proposed number 1443
Next higher square 38^2 1444

Difference ... $1 = 1^2$

Then 38   38
+ 1   − 1

Factors are ... 39 × 37 = 1443

Proposed number 57
Next higher square (8^2) 64

Difference ... 7
Add 8 × 2 + 1 (or 8 + 9) ... 17 = 24
,, 9 × 2 + 1 (or 9 + 10) ... 19 = 43
,, 10 × 2 + 1 (or 10 + 11) ... 21 = 64 = 8^2

Then 11   11
+8   −8

Factors are ... 19 × 3 = 57.

Proposed number 110467
Next higher square (333^2) 110889

Difference ... 422
Add 333 × 2 + 1 (or 333 + 334)... 667

1089 = 33^2

Then 334   334
+33   −33

Factors are ... 367 × 301 = 110467.

Jevons's proposed number 8616460799
Next higher square (92825^2) 8616480625

Difference ... 19826
Add 92825 × 2 + 1 (or 92825 + 92826) 185651 = 205477 (not a sq.)
,, 92826 × 2 + 1 185653 = 391130 (not a sq.)

therefore, add fifty-four more serial numbers, to 92880 × 2 + 1; the sum of the additions will then be found to correspond with—

$92880^2 = 8626694400$
$- 8616460799$ } $= 10233601 = 3199^2$

Then 92880   92880
+3199   −3199

Factors are ... 96079 × 89681 = 8616460799.

"C. W. M.'s" proposed number ... 3979769
Next higher square (1995^2) 3980025

Difference ... $256 = 16^2$

Then 1995   1995
+ 16   − 16

Factors are ... 2011 × 1979 = 3979769.

To find the lowest factors of 12267—

Proposed number 12267
Sum of digits being 18 it is divisible by 3^2 = 9 } = 1363
Next higher square (37^2) ... ... = 1369

Difference 6
Add 37 × 2 + 1 or 37 + 38 75

$81 = 9^2$

Then 38   38
+ 9   − 9

Lowest factors... 47 × 29 × 3 × 3 = 12267.

To find the factors of 73, by the general rule, 28 steps in the process are requisite, until the sum of additions to first difference reaches a square, $1296 = 36^2 = 37^2 - 73$.

Then 37 + 36 = 73
37 − 36 = 1 } the only factors, therefore 73 is a prime.

Instead of 28 steps being taken, the process may be shortened thus :—

Proposed number 73
Next higher square (9^2)...81

—   36   64 (even squares)

First difference ... 8 . . . 28 . . . 56
Add 9×2+1 (or 9+10)...19 (diff. 6) (diff. 2)

Second difference... 27 . . . 22 . . . 54

49   81 (odd squares).

It must be noted that the first difference (8) is an even number, and that the second (27) is an odd one. In line with 27, put down difference (22) between it and next higher odd square (49), and in line with 8, the difference (28) between it and the even square (36) next below 49. As the difference 6 (between 28 and 22) will not divide either without a remainder, the process must be repeated, with the succeeding higher even (64) and odd (81) squares, for each line, until we obtain two numbers, divisible by their difference, without remainder. In this example we find that the second step gives what is required. The difference (2) between 56 and 54, divides either.

Then $\frac{56}{2}$ = 28, and 28 + 9 (9 is first square root used) = 37;

or $\frac{54}{2}$ = 27, and 27 + 10 (10 is second sq. root used) = 37;

and 37^2 = 1369
− 73 } = 1296 = 36^2, as stated above.

The following example of a shortening process is applicable only to proposed even numbers. As such are divisible by 2, it may not be of much practical use; and only of interest to show what can be done. If the proposed number be 328, 18 steps are requisite by general rule; but 7 steps are sufficient, thus:—

Proposed number	328
Next higher square (19^2) ...	361
Difference	33

Add $2 \times 19 + 1$ (or $19 + 20$)	$39 = 72$
(or $20 + 21$)	$41 = 113$
(or $21 + 22$)	$43 = 156$
(or $22 + 23$)	$45 = 201$
(or $23 + 24$)	$47 = 248 = 8$ below 16^2.
(or $24 + 25$)	$49 = 297 = 8$ above 17^2.

It must be noted that at the 6th step the sum of additions is 248, or 8 less than the next higher square ($256 = 16^2$), and at the 7th step it is 297, or 8 more than the next lower square ($289 = 17^2$). The mean of these consecutive roots is $16\frac{1}{2}$. The consecutive square roots, corresponding for the 6th and 7th steps, are seen to be 24 and 25. The mean is $24\frac{1}{2}$.

Then $\left.\begin{array}{l} 24\frac{1}{2} + 16\frac{1}{2} = 41 \\ 24\frac{1}{2} - 16\frac{1}{2} = 8 \end{array}\right\}$ therefore 41×8 are factors of 328.

There are other short ways of working the process, varying with different numbers. For high numbers, when the difference between the factors is very great, I have not completed a shortening process that is altogether satisfactory, but I hope to succeed before long.

The examples given above are worked out by means of "increasing squares, roots, and numbers." Similar results may generally be obtained by operating with "decreasing squares, roots," &c., but I prefer the "increasing" method. To show the process by "decreasing squares," &c., I give two simple examples—

Proposed number	65
Next lower square (8^2)	64
Their sum is	129
Deduct $2 \times 8 - 1$ (or $8 + 7$) ... =	15
	114
" $2 \times 7 - 1$ (or $7 + 6$) .. =	13
	101
" $2 \times 6 - 1$ (or $6 + 5$) ... =	11
	90
" $2 \times 5 - 1$ (or $5 + 4$) ... =	9
	$81 = 9^2$

Then $\begin{array}{cc} 9 & 9 \\ +4 & -4 \end{array}$

Factors are $13 \times 5 = 65$.

Proposed number	60
Next lower square (7^2)	49
Their sum	109
Deduct $7 \times 2 - 1$ (or $7 + 6$) =	13
Mean $5\frac{1}{2}$	$96 = 4$ from 10^2 } Mean $9\frac{1}{2}$
($6 + 5$) =	11
	$85 + 4$ above 9^2 } Mean $9\frac{1}{2}$
Deduct $6 \times 2 - 1$ (or $5 + 4$) =	9
Mean $3\frac{1}{2}$	$76 - 5$ from 9^2 } Mean $8\frac{1}{2}$
($4 + 3$) =	7
	$69 + 5$ above 8^2 } Mean $8\frac{1}{2}$
Deduct $5 \times 2 - 1$ (or $3 + 2$) =	5
	$64 = 8^2$

Then $\begin{array}{cc} 8 & 8 \\ +2 & -2 \\ \hline 10 \times & 6 \end{array}$ or $\begin{array}{cc} 8\frac{1}{2} & 8\frac{1}{2} \\ +3\frac{1}{2} & -3\frac{1}{2} \\ \hline 12 \times & 5 \end{array}$ or $\begin{array}{cc} 9\frac{1}{2} & 9\frac{1}{2} \\ +5\frac{1}{2} & -5\frac{1}{2} \\ \hline 15 \times & 4 \end{array}$

Showing 3 sets of factors for 60.

A table of squares and square roots, such as Barlow's, is requisite for enabling the operator to ascertain readily, as his work proceeds, when the sum of the additions to the difference between the proposed number and the higher square, first used, becomes a square; and also to show, in connection with shortening processes, to what extent they may differ, at any step, from being square numbeis.

Whether the principle of this method or rule be useful in working algebraical or other problems I am at present unable to say, but it can no longer be said there is not a direct rule for ascertaining the factors of any number, and consequently of showing whether it be a prime or not. It may be impossible to devise an algebraical formula, but there certainly is this simple arithmetical method, applicable to all numbers.

17 Morden Road, Blackheath. CHARLES J. BUSK.

THE FORMATION OF LEDGES ON MOUNTAIN-SLOPES AND HILL-SIDES.

IT is well known that Darwin attributed to the castings of earthworms the principal part in the formation of these ledges; although he mentions in his book the case of a valley in Westmoreland, where it was "in no way connected with the action of worms." "It appeared," he concludes, "as if the whole superficial, somewhat argillaceous earth, while partially held together by the roots of the grasses, had slided a little way down the mountain-sides; and in that sliding, had yielded and cracked in horizontal lines, transversely to the slope." [1]

Ledges of this description are exceedingly common on the mountain-slopes round Caracas, and indeed almost everywhere in Venezuela. They attracted my attention on my arrival in this country, and they did so all the more as it appeared to me impossible to admit the explanation given by the people, that they were the result of the trampling of cattle, for there were no cattle grazing on these slopes, nor could anybody give me trustworthy information that such had been formerly the case. I was pretty soon convinced that this peculiar feature of the surface was due to a downward sliding of the superficial layer, and after having read Darwin's book, a copy of which I had been so happy as to receive from himself in November 1881, I at once wrote to him about the ledges, stating that I believed the real cause of their formation to be what he had suggested in the passage quoted above. (Having no copy of my letter, I cannot give the exact wording of it.) The 3rd of April (only a fortnight before he closed his great life), he answered me as follows:— "Should you observe the ledges on the mountains, I shall like much to hear the results, though I do not suppose that I shall ever again publish on the subject. Since the appearance of my book, I have become doubtful whether I have not exaggerated the importance of worms in the formation of the ledges. Perhaps they may be due to the sliding down and horizontal cracking of (the) whole of the surface soil."

Since that time I have given a good deal of attention to the subject, and the result is, at least in this neighbourhood, absolutely in accordance with this latter suggestion. There is no reason for giving any importance to the action of worms, these animals being extremely rare in the soil of the slopes. I find in my note-book only six instances of their castings having been observed; and three, when by the tearing out of plants a worm was brought to light.

Our mountains are mainly built up of gneiss, which is rather easily converted on the surface into a kind of sandy loam. This surface soil is covered by a dense

[1] Darwin, "The Formation of Vegetable Mould through the Action of Worms" (London, 1881), p. 283.

vegetation of grasses with a number of other small plants, their roots being matted together in an almost continuous mass, possessing a certain degree of elasticity. During the rainy seasons this stratum absorbs a considerable quantity of water, getting thus much softer and offering less resistance to the underlying loam and its downward thrust. The whole mass is therefore in a state of plasticity, and consequently a sliding motion begins more or less as if it were a glacier. The slope not being uniform in all its parts, nor the disintegration of the rock everywhere of the same depth and degree, it follows that the sliding too will be unequal, and so an extraordinarily complicated system of stresses and counter-stresses is developed, which of course causes the surface to take a wrinkled or wavy appearance. I have tried in vain to find numerical values for the limits of sloping which allow of the formation of these surface-waves or ledges; the fact is that it depends to a considerable degree on the interior conditions of the soil and subsoil, which are not visible from outside. The lowest slope, however, that I have seen covered with ledges, was between 8° and 10°, the steepest 45°. The total amount of sliding soil is in some places far from being insignificant. I remember a locality in this neighbourhood, where there was twenty-five years ago a shallow depression, in which during each rainy season a small pool formed with *Najas microdon*, A.Br., *Wolffia Welwitschii*, Hegelm., and even *Marsilea subangulata*, A.Br. This depression has gradually been filling up, and is now on the verge of disappearing altogether, the material having been derived from a grassy slope on its northern side, which is covered by finely developed ledges.

My observations refer to the valley of Caracas; but as identical causes must be at work in other countries, it appears to me that everywhere the formation of ledges on mountain-slopes and hill-sides will probably depend, first of all, on the conditions of the ground and its vegetation, the action of earthworms being of secondary importance.

Caracas, January 6. A. ERNST.

FIG. 1.

A MOVABLE ZOOLOGICAL STATION.

IN Bohemia, much attention has been given for more than twenty years to the study of the fauna of ponds and lakes, but the work has been rendered difficult by the impossibility of the organisms being examined instantly in their habitats. The transportation of the material a long way has led to most of the finer objects being destroyed. Last year, a little movable station, suitable for real biological work, constructed after a sketch drawn by Dr. Ant. Fritsch, was presented by Mr. Ferdinand Perner to the Committee for the Physical Exploration of Bohemia; and there is good reason to hope that the use of this structure may be attended by important scientific results. There is room (12 square metres) for from two to four workers. The building consists of eighty pieces, the total weight being 1000 kilogrammes. Two windows on the northern side are closed by wooden covers, which, when opened, present two ample working tables. The building-up of the station at the first place to which it was sent (a pond near Biechovic) required two hours and a half.

The scientific work began in the second half of June, and since that time, every week or fortnight, Dr. Fritsch with his assistants has visited the station. After the temperature of the air, and of the water on the surface and at different depths, has been noted, the surface fauna is taken by a tow-net (Fig. 2, 1). This contains mostly Copepods, Rotators, and *Daphnia kahlbergensis*, Schœdler. Then the fauna at a depth of 1 metre is taken by a net fixed on a long bamboo (Fig. 2, 2). The net contains generally the genera Daphnia, Bosmina, and Leptodora. Next, the fauna at a depth of 2 metres is taken by a long net (Fig. 2, 3), on which weights are fixed, and which is drawn out of the water by a string that closes the net by tightening it in the centre. This manipulation prevents the fauna from a depth of 2 metres from being mixed with that of the higher portions of the water. Large Daphnids are found here in great numbers. The same instrument is used in deeper parts of the pond. Mud is carried up by a strong net (Fig. 2, 4), and washed in sieves (7 and 8). The *Allona leydigii* is a common appearance there. These operations finished, the littoral fauna at various places is taken, consisting most commonly of large Sida and Lynceus. Fishing has been carried on in the same way by night, in January, under the ice-cover. Sometimes carp (*Cyprinus carpio*) have been taken at night, that the contents of their alimentary canal might be examined. The living material acquired in this manner is carefully killed by osmic and chromic acids, and preserved in strong alcohol.

The investigations will be continued throughout the year, and the results afterwards published in the *Archiv für naturwissenschaftliche Landesdurchforschung von Böhmen*. The station will, by and by, be transferred to some of the ponds in Southern Bohemia, or to one of the mountain lakes.

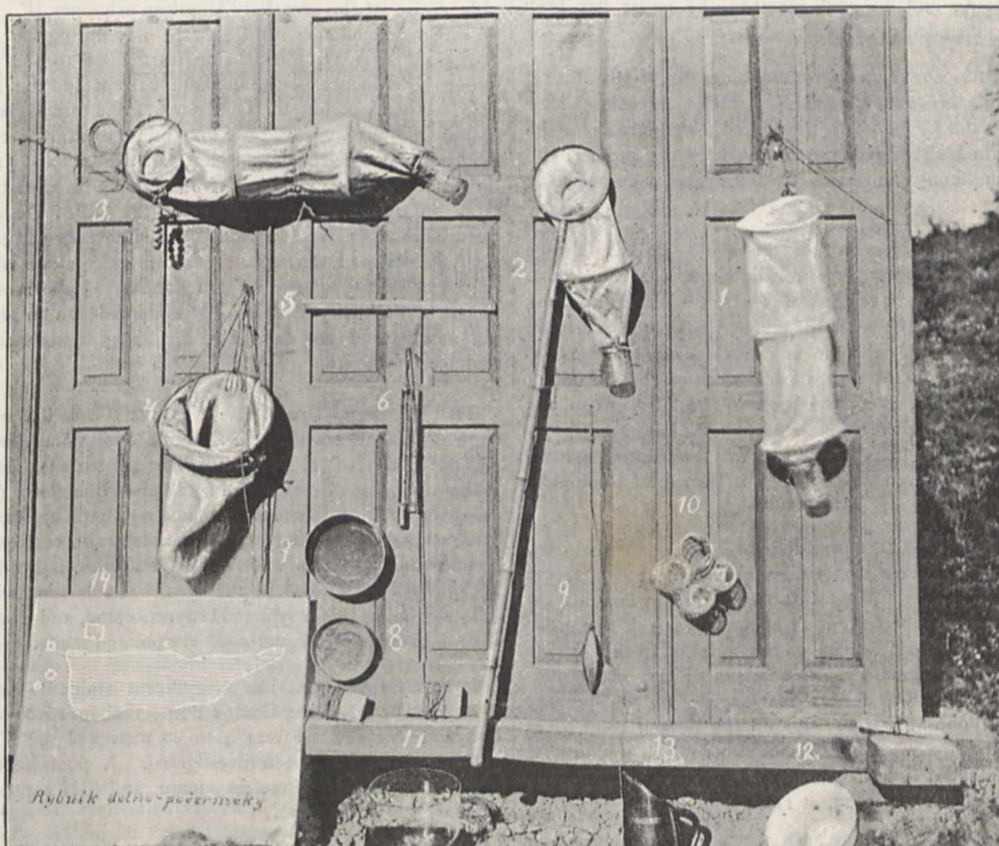

Fig. 2.

NOTES.

ARRANGEMENTS are being made by the Berlin Academy of Sciences for an interesting scientific undertaking. During the summer of this year a ship is to be despatched for the investigation of the pelagic fauna of the Atlantic, especially along the coast from Greenland to Brazil. Prof. Hensen, of Kiel, will be at the head of the party, which is expected to start in July.

THE death of M. G. Meneghini is announced. He had been Professor of Geology at Pisa from 1849, and died at the age of 78.

WE have also to record the death of Dr. Heinrich Ernst Karl von Dechen, the eminent geologist and mineralogist, well known for his numerous works on geology. He was born at Berlin on March 25, 1800, and died at Bonn on February 15.

A LADY, Mdlle. G. Cattani, has been appointed a *privat-docent* of general pathology in the Faculty of Medicine at Turin.

PROF. E. WIEDEMANN has issued a circular about a matter which has considerable interest for men of science. Journals devoted to particular branches of science very often, as he points out, reprint papers which have been originally published by scientific Societies, and omit to indicate the sources from which the papers are taken. It also happens sometimes that articles are sent simultaneously to various periodicals, and appear sooner or later in all of them, either in the original language or in translations. The consequence is that those whose duty it is to look out for the latest information on any subject are put to a vast amount of inconvenience, since it is frequently impossible for them to feel sure that communications which seem to be new are really new. Prof. Wiedemann—who has of course had much experience, in connection with the *Annalen der Physik und Chemie*, of the trouble caused in this way—appeals to men of science generally, and to the scientific Press, to indicate, in every case in which a paper is reprinted, the fact that it has appeared before, and to state whether the paper has been shortened or expanded or otherwise changed.

ACCORDING to *Die Natur*, Dr. Otto Zacharias, of Hirschberg, Silesia, intends to establish a zoological station for the observation of fresh-water fauna. It is considered that the banks of the Plöner Lake in Holstein would be suitable for the purpose, and funds for maintaining the station for four years are now being collected.

AT the half-yearly meeting of the Forth Railway Bridge Company, held the other day in Edinburgh, very favourable reports as to the progress of the works were submitted. During the past six months the work of erection has proceeded more rapidly and satisfactorily than in any previous half-year, and at the present time the total weight of steel work erected, including the viaduct approach, is 43,500 tons. The last bays of the cantilevers are in an advanced state of manufacture in the shops, and the material is being delivered for the central girders connecting the cantilevers, the erection of which will complete the bridge.

DR. HANS REUSCH, the well-known Norwegian geologist, invites through the Press reports respecting the recent severe earthquakes in Norway. From those to hand it appears that the earthquake of December 23, at 12.15 p.m., was felt along the whole coast of the North Bergenhus province and in the districts around the Stat promontory. On December 27, about midnight, another shock was felt at Bremanger; and on January 6, at 8 p.m., one at Florö, also on the Bergen coast. On January 12, at 4.7 p.m., a fourth shock was felt in and around Bergen. Finally, a shock was felt in the neighbourhood of Christiansand on December 27, at 11.44 a.m.

WE have received from the Hydrographer of the United States a discussion, by Lieut. Everett Hayden, U.S.N., of the great storm of March 11–14, 1888, known as the New York "blizzard." In NATURE, vol. xxxviii. p. 204, we referred briefly to the behaviour of this memorable storm over the land; the discussion now in question deals with its action over the ocean, and more particularly off the Atlantic coast of the United States, from all data at present available. The meteorological conditions at noon (G.M.T.) for the area included between latitude 25° and 50° N., and longitude 50° and 85° W., are exhibited on charts for each of the above four days. The charts show that on the 11th a trough of low pressure was extending from the coast of Florida towards the southern limits of Hudson Bay, and was moving towards the coast at the rate of 600 miles a day. On the morning of the 12th the centre of the storm passed almost directly over New York, blowing with hurricane force, the barometer reading 29·2 inches. On the 13th, the storm area was still skirting the coast of the United States, the centre being about midway between New York and Boston, and the barometer had fallen to 28·9 inches. By the 14th, the great wave of low barometer had overspread the entire western portion of the North Atlantic. The discussion furnishes an instructive example of a somewhat uncommon class of storms, where the usual law founded on the circular theory was to a large extent inapplicable.

THE Pilot Chart of the North Atlantic Ocean for February, issued by the Hydrographer of the United States, shows that the weather in the Atlantic during January was somewhat milder than usual. No severe storms were reported during the first three weeks of the month. There was a noticeable increase in the amount of fog encountered, but it was confined principally to the neighbourhood of the Grand Banks and the British Isles. A supplement to the Pilot Chart describes the remarkable cruise of the derelict American schooner *W. L. White*, which was abandoned off Delaware Bay during the great blizzard, on March 13, 1888. She started off to the southward under the influence of the in-shore current and the north-west gale. Upon reaching the Gulf Stream she turned away to the eastward, and commenced her long cruise towards Europe. On reaching the mid-ocean, between latitude 44° and 51° N., and longitude 33° and 44° W., she followed a remarkable zig-zag track, from the beginning of May till the end of October, being drifted backwards and forwards by the Labrador current and the Gulf Stream, and during these six months alone she was reported by thirty-six vessels. On January 23 she was stranded on one of the rocky islands of the Hebrides, after drifting for ten months and ten days, and traversing a distance of more than 5000 miles.

THE Hydrographer of the Navy has issued a notice that storm-signals are now shown at Manilla (Philippine Islands). The signals consist of (1) a drum (colour not stated), indicating a storm at a great distance, in an unknown direction; (2) a cone, point upwards or downwards, indicating that a cyclone will pass some distance to the northward or southward, respectively; (3) a cone, point upwards over or under a drum, indicating that a cyclone will pass close to the northward or southward; (4) a ball, signifying that a typhoon is approaching, and that all traffic is prohibited. The signal-staffs are painted white.

IT is estimated that the magnificent stalactite cave lately discovered near Reclère, Canton Berne, is about 1600 metres long, 600 metres broad, and from 4 to 20 metres high. The greater part of it has not yet been investigated. A pool has been discovered, measuring 25 metres square, and it is supposed to be the only one in the cave.

A WRITER in the American *Monthly Microscopical Journal*, calls attention to what seems to be a real danger in connection with the kissing of the Bible in courts of law. "The lips," he says, "are most sensitive to the reception of disease-germs, and from the motley throng of dirty and diseased persons who appear in court and kiss the book, what infectious germs may not be obtained through this medium of distribution? It would be interesting for microscopists to examine such greasy and worn backs of court Bibles as they can have access to, and to report the kinds and amounts of Bacteria found thereon. . . . In a Massachusetts school where scarlet fever and measles had prevailed, some text-books fell into disuse, were put away for a time, and, when wanted, got out and re-distributed, several months having elapsed. In but a few days after the re-issue of the books the children began to come down with measles. There can be little doubt that scarlet fever is transmitted in the same way."

SIR HENRY PEEK has compiled an interesting catalogue of his collection of birds at Rousdon. The catalogue consists of two parts. The first is accompanied by an outline index plate of each case, by means of which one may identify every bird in the case, and find out its name and some other details regarding it, by consulting the list. The second part consists of an alphabetically arranged list of both the English and the scientific names of every bird, with reference to its case, compartment, and number on the index plate, so that any particular bird required may be found without difficulty. The index plates, as Sir Henry Peek points out in the preface, save the necessity of affixing labels or numbers to the birds, which would have interfered with the artistic appearance of the groups.

UNDER the title "The True Position of Patentees," Mr. H. Moy Thomas has published, through Messrs. Simpkin, Marshall, and Co., a little book in which the patent laws and regulations at home, abroad, and in our colonies and dependencies, are explained for the information of English inventors.

MESSRS. MACMILLAN AND CO. will publish in September the Eleventh Book of Euclid, Propositions 1–21, with alternative proofs, exercises, and additional theorems and examples, by Mr. F. H. Stevens, of Clifton College, joint editor of Hall and Stevens's Euclid, Books i.–vi. Later on it is the intention of Mr. Stevens to issue a book on elementary solid geometry and mensuration, containing the matter included in the above-mentioned volume, with a section on polyhedrons and solids of revolution, treated geometrically and numerically, with exercises on the mensuration of plane and solid figures.

MESSRS. LONGMANS AND CO. have in the press "A Handbook of Cryptogamic Botany," by A. W. Bennett and George Murray. No general hand-book of Cryptogamic botany has appeared in the English language since Berkeley's, published in 1857. The present volume will give descriptions of all the classes and more important orders of Cryptogams, including all the most recent discoveries and observations.

A NUMBER of remarkable salts of hydrazine or amidogen have been prepared by Drs. Curtius and Jay, in the course of their work upon the hydrazine compounds, which has so successfully resulted, as noticed in these columns a fortnight ago (p. 377), in the isolation of the hydrate of amidogen, $N_2H_4 . H_2O$. Amidogen, as indicated by the strong alkalinity of its hydrate, and by the well-known reactions of its organic substitution-products, is a powerful base, and combines with acids to form salts of considerable stability at ordinary temperatures. Perhaps the most interesting of these salts, and the one utilized for the preparation of the liquid hydrate itself, is the di-hydrochloride, $\begin{matrix} NH_2 . HCl \\ | \\ NH_2 . HCl \end{matrix}$. This salt possesses a most striking resemblance to ammonium chloride, crystallizing in the cubic system, and depositing, on rapid evaporation, in the same beautiful feathery forms. It differs, however, from ammonium chloride in being very deliquescent. When heated to 198° C., it fuses, with evolution of hydrochloric acid, to a clear glass consisting of the mono-hydrochloride, $\begin{matrix} NH_2 . HCl \\ | \\ NH_2 \end{matrix}$. On further heating to 240°, it is entirely decomposed, with evolution of free nitrogen and hydrogen and sublimation of ammonium chloride—

$$2 \begin{matrix} NH_2 . HCl \\ | \\ NH_2 . HCl \end{matrix} = 2NH_4Cl + N_2 + H_2 + 2HCl.$$

Contrary to the usual behaviour of bases of the ammonium type, platinum chloride in acid solution gives no platinochloride; the reducing action comes so violently into play that the platinic salt is reduced to platinous chloride, with copious evolution of nitrogen gas. The sulphate, $\begin{matrix} NH_2 \\ | \\ NH_2 \end{matrix} . H_2SO_4$, like ammonium sulphate, is anhydrous, and crystallizes in optically biaxial prisms. It is the most insoluble of the hydrazine salts in cold water, and is precipitated from cold solutions of all the other investigated salts by dilute sulphuric acid; it readily dissolves, however, in hot water. On heating it melts at 254° with explosive evolution of gas, breaking up into ammonium sulphite, sulphurous acid, sulphuretted hydrogen, and, most remarkable of all, large quantities of free sulphur. The carbonate is obtained by saturating a solution of the hydrate with carbonic acid gas, and evaporation *in vacuo* as a highly deliquescent mass. The nitrate can readily be obtained from the carbonate by treatment with nitric acid; it crystallizes well, and is also extremely soluble. The acetate and oxalate have also been obtained in fine crystals. All these salts possess the same exceptional reducing powers, free nitrogen and water being formed in the process. They all decompose on heating with formation of salts of ammonium, and of gaseous nitrogen and hydrogen. One of their most important properties is their reaction with nitrous acid; on mixing any salt of hydrazine with a salt of nitrous acid, free nitrogen is evolved with almost explosive violence. It is finally of considerable significance that those which crystallize well appear to be isomorphous with the corresponding ammonium salts.

A BELGIAN, M. Nizet, of the Royal Library of Brussels, proposes to issue a periodical catalogue or table of all papers published in all the periodicals in the world. Of course the titles of the papers are to be methodically grouped under a certain number of divisions.

THE following are the arrangements for science lectures at the Royal Victoria Hall during the month of March:—Tuesday, March 5, "A Visit to the Moon: how we got there and what we saw," by Prof. Carlton Lambert; Tuesday, March 12, "A Tramp among the Mountains at Home and Abroad," by Prof. Kennedy, F.R.S.; Tuesday, March 19 and 26, two lectures, by Prof. H. E. Armstrong, on the "History of a Crime unravelled by a Piece of Rusting Iron, a Horse-shoe, and a Match."

THE *Indian Forester*, in a review of the work of the Forest Department under the rule of Lord Dufferin, says that the total number of prosecutions for offences against the forest laws has been steadily diminishing. The area under protection from fire has risen from 15,570 to 18,691 square miles. Large areas have been withdrawn from nomadic grazing; and, generally speaking, the old and wasteful methods have been displaced by an entirely new system, which is only now making itself felt. The influence of forest conservancy on the rainfall, the temperature, and the water-supply is becoming appreciated by the people of India. Large additions have been made to the teak plantations of Burma, and great quantities of mahogany have been planted at Nilambur. The revenue has risen from 67 lacs in the years 1876–80, to 94 lacs during the viceroyalty of Lord Ripon, and to 116 during that of Lord Dufferin. These figures do not include the money received from Upper Burma, where the loosely-drawn leases have given infinite trouble to the officials. The staff is too weak for the work, but a re-organization scheme is under consideration. The forest class at Cooper's Hill, and the working of the Dehra Dun School, will no doubt improve the standard of knowledge of the officials.

IN the recent Report of the Bombay Chamber of Commerce it is said that the opinion of the Chamber was solicited as to the advisability of introducing a uniform standard of weight throughout the Presidency. A Committee was appointed, but there was some difference of opinion amongst the members as to the most convenient standard. Some were in favour of adopting the scale used by the railway companies in Bombay—that is, 180 grains = 1 tola, and so on up to 1 candy; but the majority thought that the English system of hundredweights, quarters, and pounds would be the best, and to this view the Chambers of Commerce of Bengal, Madras, and Kurrachee have assented. The Committee, however, refrained from urging on the Government to alter the present standards. The Government of India have appointed a Commission to inquire into the whole matter.

M. Resin has published, in the *Izvestia* of the Russian Geographical Society, interesting sketches of the natives of Kamchatka, made during a cruise on the schooner *Sibir*. It appears that the Kamchadales and the Aleutes are rapidly abandoning their mother language, and speak a very broken Russian—the more broken as the Russians themselves, in order to be better understood, speak a language which has hardly any likness to their mother tongue. The population of Kamchatka, which was carefully registered in 1878 and 1879, shows a regular decrease; since the time of Krasheninnikoff's journey (in 1741) the population seems to have been reduced to one-half of what it was 148 years ago. Years of scarcity of fish, the staple food of the population, are quite common. In such cases the Lamutes and the Koryaks usually bring to the Kamchadales a number of their reindeer; but this voluntary help is not sufficient to prevent starvation. Hunting becomes less and less profitable. The following figures represent the results of hunting during the winter of 1884-85: 2,915 sables, 159 foxes, 321 otters, 302 ermines, 120 mountain sheep, and 767 reindeer. It is noteworthy that no diminution of population is remarked among the Tchukches on the coasts of the Arctic Ocean.

Last week we quoted from Prjevalsky's "Fourth Journey to Central Asia" a description of fiery sunsets he had observed in crossing the Gobi. The same work contains the following remarks as to the action of wind upon the soil in the deserts of Central Asia:—"One must see the wind blowing in the desert to appreciate its force. Not only dust and sand fill the atmosphere, but sometimes smaller gravel is lifted into the air, while larger stones are rolled over the surface of the soil. At the foot of the Altyn-tagh, in the neighbourhood of the Lob-nor, we saw how stones as big as a man's fist, having been whirled into the hollow of a larger piece of rock by the storm, were making deep holes, and had even pierced through a slab of sandstone 2 feet thick." In accordance with Richthofen's views, Prjevalsky was inclined to explain the formation of loess by the force of wind, but he was not aware of the geographical distribution of loess—that is, its disposition as a girdle along the foot of all the mountains of Central Asia, and its absence on the plateaus, even in the parts which are protected from wind. On the other hand, the winds of the desert really afford an explanation of the strange coarse gravel, quite devoid of any particles of finer sand and loam, which covers the Gobi. The winds must have blown away the finer parts of the gravel.

We have received the Triennial Calendar of the Tungwen College of Pekin, at which over a hundred students are prepared for the Government service. The full course, literary and scientific, extends over eight years, the first three being devoted exclusively to foreign languages, and the remainder to the acquisition of scientific and general knowledge through the medium of these languages. After the completion of the general course, students may, if they please, remain in the College, or be sent abroad at the option of the Government, for the pursuit of special studies with a view to professional use. The method of paying the students is thus described in the Calendar:—The object of the College being to train men for special service, the number is limited, and all admitted are, with a few exceptions, paid by the Government. During the first year the student is on probation, and receives his food and lodging only. He then gets an allowance of about three taels (14*s.* or 15*s.*) a month. In two or three years this stipend is doubled if the student progresses satisfactorily, and it is again increased to ten taels a month at the end of five or six years. If a student is sent to pursue his studies in foreign countries, the allowance is one hundred taels a month, which is increased to two hundred taels when he is made a third-class interpreter. The preparation of books for the diffusion of scientific and general knowledge is part of the work of the College. Amongst those prepared and published already are works on natural philosophy, chemistry, practical economy, chemical analysis, mathematical physics, anatomy, astronomy, &c.

In the "Note" last week about a Greenland whale which went ashore in the Sound (p. 398), *for* "90 feet in length" *read* "60 feet in length."

The additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus* ♀) from India, presented by Mrs. Nicol; an Indian Chevrotain (*Tragulus meminna* ♀ juv.) from India, presented by Mr. George Score; a Hybrid Polecat (between *Mustela putorius* and *M. furo*), British, presented by Mr. J. Herbert B. Cowley; an Owen's Apteryx (*Apteryx oweni*) from New Zealand, presented by Prof. T. Jeffrey Parker, C.M.Z.S.; a Common Buzzard (*Buteo vulgaris*) from Spain, presented by Captain J. V. Harvey; eight Common Swans (*Cygnus olor*), European, deposited; seven Common Gulls (*Larus canus*), from Holland, five White's Tree Frogs (*Hyla cærula*) from Australia, purchased; a Collared Fruit Bat (*Cynonycteris collaris*), born in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1889 MARCH 3-9.

(**For the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.**)

At Greenwich on March 3

Sun rises, 6h. 42m.; souths, 12h. 12m. 3·0s.; sets, 17h. 42m.: right asc. on meridian, 22h. 57·9m.; decl. 6° 37′ S. Sidereal Time at Sunset, 4h. 29m.

Moon (at First Quarter on March 9, 18h.) rises, 7h. 48m.; souths, 13h. 35m.; sets, 19h. 35m.: right asc. on meridian, 0h. 20·7m.; decl. 3° 6′ S.

Planet.	Rises. h. m.		Souths. h. m.		Sets. h. m.		Right asc. and declination on meridian. h. m.		° ′
Mercury..	5 47	...	10 36	...	15 25	...	21 21·9	...	14 18 S.
Venus.....	7 39	...	14 57	...	22 15	...	1 43·8	...	14 6 N.
Mars......	7 30	...	13 54	...	20 18	...	0 40·5	...	3 56 N.
Jupiter....	3 37	...	7 33	...	11 29	...	18 18·4	...	23 4 S.
Saturn....	14 46	...	22 23	...	6 0*	...	9 10·9	...	17 30 N.
Uranus...	21 12*	...	2 36	...	8 0	...	13 20·1	...	7 45 S.
Neptune..	9 22	...	17 5	...	0 48*	...	3 51·4	...	18 29 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Mar.		h.		
4	...	0	...	Mars in conjunction with and 5° 2′ north of the Moon.
5	...	11	...	Venus in conjunction with and 8° 57′ north of the Moon.
5	...	20	...	Venus at least distance from the Sun.

Saturn, March 3.—Outer major axis of outer ring = 45″·2; outer minor axis of outer ring = 12″·5: southern surface visible.

Meteor-Showers.

	R.A.		Decl.		
Near Capella...	50°	...	48° N.		
From Coma Berenices...	190	...	25 N.	...	March 8.
Near γ Herculis	244	...	16 N.	...	March 7. Very swift.

Variable Stars.

Star.	R.A. h. m.	Decl. ° ′			h. m.	
U Cephei	0 52·5 ...	81 17 N. ...	Mar.	4,	18 8	*m*
R Arietis	2 9·8 ...	24 32 N. ...	,,	4,	.	*M*
Algol	3 1·0 ...	40 32 N. ...	,,	3,	2 41	*m*
			,,	5,	23 30	*m*
R Canis Majoris ...	7 14·5 ...	16 11 N. ...	,,	3,	21 6	*m*
		and at intervals of			27 16	
V Geminorum ...	7 16·9 ...	13 18 N. ...	Mar.	3,		*M*
V Leonis	9 53·9 ...	21 47 N. ...	,,	9,		*M*
U Coronæ	15 13·7 ...	32 3 N. ...	,,	4,	2 50	*m*
T Herculis	18 4·9 ...	31 0 N. ...	,,	7,		*m*
β Lyræ...	18 46·0 ...	33 14 N. ...	,,	4,	22 30	*M*
			,,	8,	4 0	m_2
R Lyræ	18 52·0 ...	43 48 N. ...	,,	5,		*M*
Y Cygni	20 47·6 ...	34 14 N. ...	,,	4,	5 40	*m*
			,,	7,	5 40	*m*
δ Cephei	22 25·0 ...	57 51 N. ...	,,	7,	3 0	*M*

M signifies maximum ; *m* minimum ; m_2 secondary minimum.

GEOGRAPHICAL NOTES.

THE paper read at Monday's meeting of the Royal Geographical Society was by Captain Vangèle, giving an account of his exploration of the Welle-Mobangi river, the great northern tributary of the Congo. His first exploration was made in the end of 1886 in a flat-bottomed boat, the *Henry Read*, with a stern paddle-wheel. On this first journey Captain Vangèle did not succeed in getting beyond Mr. Grenfell's furthest, the Zongé Falls, just where the river turns sharply to the east. He gives an interesting account of the Ba-Ati, the people who inhabit the banks of the river, and who are in every way of a superior type, though cannibals. A little distance above its mouth the Mobangi or Ubangi measures about 2730 yards in breadth ; its greatest depth is 5 fathoms, its lowest 1 fathom ; it flows at the rate of 3¼ feet a second. Under the 4th degree, just below the rapids, it still has a breadth of 1300 yards, a depth of 4 fathoms, and a velocity of 4 feet a second. Between these two points, though continually varying in breadth, it never exceeds about 4000 yards, including the islands. The general appearance of the river is pretty much the same as that of the Congo near Bolobo—strewn with islands, and having low wooded banks. The colour of the water is a light brown. Captain Vangèle's second journey was made a year later, and with better means of forcing his way up the rapids of the Mobangi. This time, though he encountered several obstacles, he managed to push his way up the river to over 22° E. longitude, and to within sixty miles of Junker's furthest point on the Wellé. This has been accepted as clearly proving the identity of these two rivers, so that the long-standing problem of the Wellé may be regarded as solved. At his furthest point Captain Vangèle had to turn back owing to the hostility of the natives, the only instance in which he met with real opposition. Between rocks and islands, rapids and cataracts, the navigation of the lower Mobangi is beset with difficulties, though it is evidently practicable with suitable vessels, and a thorough knowledge of the river. The river is subject to great variations of level, according to the season of the year. Above the Zongo Falls, the people, named Bakombé, differ considerably from those on the lower river, and evidently spread far inland. From above the Zongo rapids the river opens out, flowing straight from the north-east, and the outlook is described as superb. It is free from all obstacles, from 900 to 1000 yards wide, with a depth of 12½ fathoms, flowing between banks 6 to 10 feet high, grassy plains alternating with clusters of trees. After thirty miles in the north-east direction the river turns due east, which direction it maintained to the end of the voyage, 170 miles. The banks are densely inhabited, and provisions of all kinds abound. Between the Zongo Falls and the steamer's furthest point only one tributary was met with—the Bangasso—coming from the north. After the paper was read, Sir Francis De Winton made some remarks with regard to the position of Mr. Stanley. He totally disbelieves the conjecture of Lieut. Baert that Stanley has any intention of taking Khartoum. On the contrary, Sir Francis believes he is now on his way home by the east coast.

IN the last issued number (4e trimestre, 1888) of the *Bulletin* of the Paris Geographical Society will be found a very complete examination of the route for a proposed Euphrates Valley Railway, by M. A. Dumont. M. Adrien Blondel contributes a detailed account of the Island of Réunion. M. Jules Marcou, in concluding his paper on the origin of the name of America, decides against Vespucci and in favour of an aboriginal placename.

IT has been arranged that the eighth German *Geographentag* shall be held at Berlin from April 24 to 26 next.

THE *Ceylon Observer* states that Mr. Stephens, who has recently been amongst the Veddas of Ceylon, and who subsequently explored New Guinea, is now in Ceylon on his way to Singapore to organize an expedition at the instance of Prof. Virchow to explore the unknown portions of the Malayan Peninsula. Mr. Stephens's instructions are to start from Malacca and travel north-north-west through the vast expanse of unexplored territory which stretches northwards for some 500 miles. There are on the coast various settlements near mines and plantations, but the greater portion of the interior has been hitherto unexplored. The inhabitants are said to be jealous and bloodthirsty.

M. LŒWY'S INVENTIONS AND RESEARCHES.[1]

IT is now my pleasing duty to lay before you the grounds on which the Council have awarded the gold medal to M. Maurice Lœwy for his invention of the equatorial *coudé*, of a new method of determining the constant of aberration, and for his other astronomical researches.

On examining the series of memoirs in which M. Lœwy has set forth his new methods of astronomical research, we are at once impressed by the originality of conception which characterizes all his ideas, and by the thoroughness with which he has worked out the details necessary for the practical application of his new methods of observation. Observational astronomy has for many years past proceeded on such well-defined lines, that we have not unnaturally come to look rather to improvements of detail than to the introduction of new instruments for the advancement of our knowledge. It is, therefore, a matter of great satisfaction to find that M. Lœwy has placed at our disposal various methods of observation based on entirely new principles, and calculated to give astronomers improved and quite independent means of attacking several of the most important problems in our science.

The first of these new instruments with which I will deal is the equatorial *coudé*.

It was in the year 1871 that M. Lœwy proposed his new form of equatorial, to which the name of "equatorial *coudé*" has been given, and M. Delaunay, then Director of the Paris Observatory, was so struck with the value of the principle that he arranged for the construction of an instrument on this plan. M. Delaunay's death, however, interrupted the work, and the first equatorial *coudé*, having an object-glass of 0·27 metre, or about 10⅝ inches aperture, was not completed till the year 1882. The success of this instrument was so marked that its value could not fail to be recognized, and it was not long before the construction of several larger equatorials on the same principle was commenced. At the present time six equatorial *coudés* have been completed, and four of these are already mounted and in regular use at the Observatories of Paris, Lyons, Besançon, and Algiers. The other two are intended for the Observatories of Paris and Vienna.

In principle the equatorial *coudé* may be described as an adaptation of the form of transit instrument with axial view to the requirements of an equatorial, by the addition of a plane mirror inclined at 45° outside the object-glass, this mirror being capable of rotation about the axis of the telescope, so as to reflect into the latter the rays from any object in a perpendicular plane. The axis of the instrument is mounted as a polar axis between two piers, the telescope being broken at a right angle near the lower pivot, so that the rays from the object-glass are reflected by an internal mirror up the polar axis to the hollow upper pivot, where the image is formed. The rotation of the outer mirror thus brings into the field the image of any object in the hour-circle perpendicular to the object-end of the telescope, and by the rotation of the polar axis, as in an ordinary equatorial, the telescope is directed to any hour-angle. The declination-axis in the equatorial *coudé* is the axis of the object-end of the telescope about which the outer mirror turns, and the declination-circle placed at the eye-end, in the same plane with

[1] Address delivered by the President of the Royal Astronomical Society, Mr. W. H. M. Christie, F.R.S., Astronomer-Royal, on presenting the Gold Medal of the Society to M. M. Lœwy at the anniversary meeting on February 8, 1889.

the hour-circle, is connected with the axis of the outer mirror by gearing, so that the observer at the stationary eye-piece has both the hour and declination circles immediately under his eye. He can thus direct the instrument to any object without moving from his chair, and his observations are made under the most favourable conditions for his own comfort, similar to those under which the microscope is used by the student of natural history. The observing-room, which may be artificially warmed, is quite separated from the object-glass, and other external parts of the instrument. These latter are protected from the weather by a suitable hut, which can be rolled away on rails before observing, so that the optical parts of the equatorial are in the open air under the best conditions for establishing an equilibrium of temperature.

The importance of obtaining the favourable conditions for observation secured by M. Lœwy's equatorial *coudé* has long been recognized, and various attempts have been made to enable the observer to command any part of the sky without changing his position. In 1858, Dr. Steinheil proposed[1] a new method of mounting a reflector, so that the axis of the concave mirror formed the polar axis, the rays from a star being reflected down the axis to the concave mirror by a plane mirror, which could be rotated about a declination-axis and a polar axis. The observer looked down the polar axis through a hole in the plane mirror, but with this arrangement he could not observe stars much north of the equator unless the plane mirror were made very large, and the range of the equatorial was thus very restricted. A more extended range might be obtained by interchanging the concave and plane mirrors, so that the observer would look up in the direction of the pole; but the concave mirror and its support would block out the view of the region near the pole, and of all the sky below the pole. Sir H. Grubb has applied the same principle to the construction of a siderostatic refractor.

As compared with Dr. Steinheil's form, the equatorial *coudé* possesses the great advantage of commanding every part of the sky, the arm of the telescope below the elbow being made long enough to project beyond the sides of the observing-room when viewing objects near the meridian.

The siderostat of Foucault, though useful for many purposes, is open to the same objection as Dr. Steinheil's, of not permitting of a view of every part of the sky; and there is the further difficulty that the apparent direction of the diurnal motion is continually changing. In the equatorial *coudé* this direction changes with the declination, but M. Lœwy has now arranged that the micrometer is turned with the declination-circle, and is thus always set to the zero of position-angle.

The success obtained by M. Lœwy in the construction of the equatorial *coudé* is due to the following circumstances:—

(1) The absence of flexure in the mirrors, which are made much thicker than usual.

(2) The more perfect achromatism secured by the greater focal length which this form of mounting allows of.

The first condition was established by careful experiment, which showed that in order to avoid deformation by flexure the thickness of a mirror should be between one-fifth and one-sixth of the diameter, instead of one-ninth or one-tenth as had been usual hitherto.

As regards achromatism, M. Lœwy urges that, in order to be able to see better with a larger object-glass, the achromatism must be made more perfect, and that, therefore, the ratio of focal length to aperture must increase with the aperture in order to diminish the effect of the secondary spectrum.

Notwithstanding the two reflections, the definition obtained with the equatorial *coudé* appears to be very good, the components of ω Leonis, distant only 0''·5, having been separated with the Paris instrument, which has an object-glass of 0·27 metre or about 10⅝ inches. With one of the new instruments of 0·31 metre, or 12¼ inches aperture, M. Trépied, at Algiers, easily divided γ^2 Andromedæ. The loss of light by the two reflections from silvered mirrors is computed by M. Lœwy at only 12 per cent., and it would seem that it is at any rate very small, as successful observations of a minor planet of 13·5 magnitude were obtained with the Paris instrument as well as of very faint nebulæ and comets. The comet 1885 *d* (Fabry) was discovered with this instrument.

One of the objects which M. Lœwy had in view in planning his equatorial *coudé* was to obtain greater stability than is attainable with ordinary equatorials, and to make the measurement of large angular distances possible. The form of mounting of the equatorial *coudé* seems peculiarly adapted to give great stability, provided the fixity of the mirrors in their cells can be secured, and this is a condition to which M. Lœwy has given special attention. Each mirror rests in its cell on thick felt or flannel, and is held by three clips, which are just brought into contact with it when in the horizontal position, as tested by the disappearance of the least trace of light between the clip and its reflected image. This adjustment being made for the horizontal position, in which the weight of the mirror has its full effect, perfect contact between the mirror and its clips will be maintained in all positions.

M. Lœwy, in conjunction with M. P. Puiseux, has investigated very completely the theory of the instrumental adjustments of the equatorial *coudé*, including the effect of flexure of the polar axis and of the telescope arm, and has shown the relation of his formulæ to those for ordinary equatorials. He arrives at the two following conditions of optical adjustment as sufficient for astronomical purposes:—

(1) The axis of the telescope arm should be perpendicular to the polar axis.

(2) The interior mirror should reflect to the centre of the field a ray entering the telescope along the axis of the arm, supposed to be perpendicular to the polar axis.

The discussion of the instrumental errors of the Paris instrument, partly by astronomical observations, and partly by means of a collimator attached to the mounting of the exterior mirror, shows a very satisfactory accordance in the determinations on different days, and in the result the instrumental errors were found to be very small, the largest amounting only to 23''. The coefficients of flexure are, however, rather larger quantities, being 91'' and 53'' for the polar axis and telescope arm respectively, as found by means of the collimator. It may be expected that in the new instruments the effects of flexure would be very much less, as important improvements have been made in their mechanical construction.

It is not a little remarkable that the first instrument made on this new principle should have given such excellent results, both optically and mechanically; and its success is evidence of the thoroughness with which M. Lœwy has worked out his idea, and of the skill with which MM. Henry and M. Gauthier have respectively carried out the optical and mechanical portions of the instrument.

I now pass on to M. Lœwy's new method of determining the constant of aberration. It is hardly necessary to insist on the importance of this constant, not only for obtaining the true positions of the stars, but, in a higher degree, for the determination of the solar parallax by means of the velocity of light. It must be admitted that the nine independent determinations of the constant of aberration made at Pulkowa with three different instruments show a satisfactory accordance, but in the opinion of M. Nyrén, who has published the latest researches on the subject, none of these can be asserted to be free from systematic error. M. Nyrén's definitive value is 20''·492, exceeding by 0''·047 W. Struve's original value, which has hitherto been generally used by astronomers. Under these circumstances, M. Lœwy's method, which is based on differential measures with an equatorial, constitutes a new departure of great value in astronomy of precision, and its value is enhanced by the circumstance that it is also applicable to the determination of the constant and law of refraction.

The principle of M. Lœwy's method is the measurement of the angular distance between two stars by means of a double mirror, formed by silvering two faces of a large prism of glass and placed in front of the object-glass of an equatorial. The double mirror is capable of rotation about the axis of the telescope, so that by reflection from the two silvered surfaces the images of two stars in different parts of the sky may be brought into the field side by side, and the distance between them measured in the direction of the common plane of reflection. In his memoir on the determination of refraction by the new method, M. Lœwy proves that the projection of the distance between the two images on the trace of the common plane of reflection is independent of the rotation of the equatorial, of any movements of the double mirror, and of the displacement of the images by the diurnal motion, when the observation is not made rigorously in the plane of reflection.

M. Lœwy's exposition of his method of determining the constant of aberration is contained in a series of communications made to the French Académie des Sciences and published in the *Comptes rendus*, vols. civ. and cv. In giving an account of this

[1] *Astron. Nachrichten*, No. 1138; *Monthly Notices*, vol. xix. p. 56.

investigation, I will proceed at once to the general method for determining aberration, which M. Lœwy discusses after treating some special cases.

The determination of aberration requires the measurement of the distance between a pair of stars at successive epochs when the effect of aberration on the angular distance is reversed. The observations are made when the two stars have the same altitude, so that the effect of refraction is a minimum, and the comparison of the two measures gives a multiple of the constant of aberration, which is independent of all instrumental errors and also of precession and nutation, as the distance between two stars is unaffected by any movements of the earth's axis or of the ecliptic. There is the further advantage in the new method, that the effect of aberration as measured is much greater than in the ordinary methods of observation.

But the result might be affected by change of refraction or by alteration in the angles of the double mirror resulting from thermal expansion between the two epochs of observation, and M. Lœwy has therefore imagined a general method of observation which eliminates any possible effects of the kind, as well as methods applicable to special cases which determine any changes due to refraction or expansion of the mirror.

The essence of the general method is that two pairs of stars are observed, the four stars being selected so that at the time of observation they are all simultaneously at the same altitude, and that the effects of aberration on the two arcs connecting the stars of each pair are large and of opposite sign. Thus the two arcs formed respectively by the two pairs of stars are compared simultaneously both at the first and at the second epochs.

The first point for investigation is the effect of aberration on the angular distance between a given pair of stars. From the geometrical conditions, M. Lœwy arrives readily at the result that the effect is proportional to the cosine of the angle between the median [1] of the arc and the direction of the earth's motion.

Calling Δ the angular distance between two stars, p the angle between the median of the arc joining them and the direction of the earth's motion, and k the coefficient of aberration, the effect of aberration is given by the formula—

$$d\Delta = 2k \sin \frac{\Delta}{2} \cos p.$$

It readily follows from this that the effect of aberration on the difference of the two arcs connecting two pairs of stars will be greatest when the two medians are on the same vertical circle on opposite sides of the zenith. Under these circumstances, the effect of aberration on the difference of the two arcs is equal to

$$4k \sin \frac{\Delta}{2} \sin \frac{\Delta'}{2} \cos L,$$

Δ' being the angular distance between the two medians, and L the angle between the direction of the earth's motion and the line of intersection of the vertical plane through the medians with the horizon. Thus the effect is proportional to the cosine of this angle, and the greatest effect will be obtained when the vertical plane of the medians, the ecliptic and the horizon intersect in the same line, and the observations are made at the two epochs six months apart when the direction of the earth's motion coincides with this line, L having the values 0° and 180° at the two epochs respectively. In that case the effect of aberration on the difference of the two arcs has opposite signs at the two epochs, and the comparison of the two sets of measures of the two arcs gives

$$E = 8k \sin \frac{\Delta}{2} \sin \frac{\Delta'}{2},$$

where E is the difference of the two measures of difference of arcs at the first and second epochs respectively.

The next point for consideration is the choice of the angle for the double mirror, their angular distance (Δ) between the two stars in each pair being necessarily twice this angle. Obviously the altitude at which the observation of the four stars is made diminishes as Δ and Δ' increase, and M. Lœwy shows that the maximum effect at any given altitude is obtained by making $\Delta' = \Delta$, or the angular distance between the medians the same as that between the two stars in each pair. He then gives the following table of the altitude h and of the effect of aberration $\frac{E}{k}$ corresponding to the several values of the angle of the double mirror α :—

α	30°	35°	40°	45°	50°	55°	60°
h	48° 35′	42° 9′	35° 58′	30° 0′	24° 24′	19° 12′	14° 29′
$\frac{E}{k}$	2·0	2·6	3·3	4·0	4·7	5·4	6·0

M. Lœwy concludes that the angle of the double mirror should not exceed 50°, and he considers that, on the whole, it would be well to make it 45°, so that the altitude of the stars would be 30°, and the angular distance for each pair 90°. Under these conditions, observations made at two epochs six months apart would give as the quantity measured four times the constant of aberration, while the ordinary methods of observation only give at the maximum a measure of twice the constant. But, in order to avoid daylight observations, M. Lœwy thinks it would be advisable to be satisfied with a slightly smaller coefficient of k (the constant of aberration), say three instead of four, which would reduce the interval between the two epochs to about ninety-eight days; and, by combining the observations in the first five weeks with those in the last five, a series of equations would be obtained, in which the coefficient of k would vary from three to one, the mean value being about two. All the observations could then be made in the night hours.

Besides the general method of observation just described, M. Lœwy has, as already mentioned, devised two methods applicable to special cases which are well suited to give independent determinations of the constant of aberration.

The first method consists in the observation of two pairs of stars, of which one pair gives, at the end of two or three months, the measure of twice the constant of aberration, and the other, completely unaffected by aberration, exhibits the effect of temperature on the double mirror. The first pair of stars should be in the neighbourhood of the ecliptic; the second pair is, as will be seen from geometrical considerations, to be chosen so that the latitudes of the two stars are the same, and that their longitudes differ by 180°, in order that the arc joining them may be unaffected by aberration.

This method is, however, not applicable at observatories within 20° of the equator, and on this account, as well as to give another independent determination of the constant of aberration, M. Lœwy proposes a second method, according to which the angular distance of a single pair of stars near the ecliptic is to be observed for a period of three months or longer, the measures in the first and last twenty-five days of the period being used to determine the aberration, and those in the intermediate forty days to deduce the effect of temperature on the double mirror.

The question of the adjustment of the double mirror remains to be mentioned. This must be mounted so as to turn about the optical axis, and this axis should coincide nearly with the axis of figure. The effects of any movements of the double mirror will then be as follow :—

(1) In turning round the axis of figure the two images are displaced in opposite directions, but perpendicularly to the trace of the common plane of reflection.

(2) In turning round an axis in this plane and perpendicular to the axis of figure the two images move in the same direction perpendicularly to the trace of the plane of reflection.

(3) If the double mirror turns about an axis perpendicular to the plane of reflection, the two images move along the trace without changing their relative distance.

Reference has already been made to the applicability of M. Lœwy's new method to the determination of refraction at various altitudes. This was, in fact, the immediate object which M. Lœwy had in view when he devised the method, and his investigation of the conditions of the problem was communicated to the French Académie des Sciences early in 1886, the year before he published his memoir on aberration.

In his series of papers on the determination of refraction published in the *Comptes rendus*, vol. cii., M. Lœwy first gives a method for determining the constant of refraction, the law according to which refraction varies with the altitude being known. A pair of stars is observed when refraction has its maximum effect on their angular distance, and again when the effect of refraction is a minimum. For the maximum effect one of the stars must be on the horizon, and the other in the same

[1] The median is the line bisecting the angle between the directions of the two stars.

vertical circle with it, while for the minimum both stars must be at the same altitude. M. Lœwy then finds that the greatest variation of refraction will be obtained with an angle of 30° for the double mirror, but as with this there would be (for the latitude of Paris) a minimum interval of 6h. 35m. between the two epochs of observation, he prefers to take an angle of 45° for the double mirror, sacrificing only 15″ in the effect of refraction, while reducing the interval between the observations to 4h. 44m. This is the minimum value of the interval found by selecting the pair of stars so that their common zenith distance at the second epoch is equal to the angle of the double mirror, or half the angular distance between the two stars.

The geometrical conditions thus found by M. Lœwy to give the maximum effect in the minimum interval of time between the observations may be somewhat modified in practice, provided the angular distance between the stars does not differ by more than a few minutes from twice the angle of the double mirror. M. Lœwy has thus been able to find some twenty pairs of bright stars suitable for the determination of refraction by this method. In its practical form the method consists in the measurement of the angular distance between a pair of stars 90° apart when one of the stars is near the horizon and the other near the zenith, and again when both the stars are at about the same altitude. It is not necessary that at the former epoch the low star should be very near the horizon, for, as M. Lœwy points out, observations may be advantageously continued till the altitude is nearly 20°, and thus the constant of refraction may be determined from observations which are practically unaffected by any uncertainty in the law of refraction.

It will readily be understood that the observation of the low star may be made either when it is rising or when it is setting. In the latter case the observation of the stars at equal altitude would precede that for which one of the stars is setting. By combining the observations of two pairs of stars chosen so that the first pair is rising when the effect of refraction on the second is a minimum, and that the first pair is at the minimum when the second pair is setting, the influence of any change in the angle of the double mirror will be eliminated by taking the mean of the two determinations, while the difference of these will give four times the change of angle in the interval, thus affording a precise determination of any such change, if it exists.

Various other methods are proposed by M. Lœwy for determining the refraction at any altitude without assuming its law of variation. These methods, however, appear to involve practical difficulties, as they either assume the absence of irregular variations in the refraction at an altitude of 10°, or require the construction of several double mirrors with different angles. They may be considered as supplementing the first method; and they are of interest as giving a direct measure of refraction independently of any theory.

The practical determination of the constants of aberration and refraction by the new method is being carried out by M. Lœwy and M. P. Puiseux with the equatorial *coudé* of the Paris Observatory, and the series of observations made during the past twelve months confirms in the most satisfactory manner the theoretical conclusions. M. Lœwy finds that the variations of the distances are really free from systematic errors, and he considers that the constant of refraction will be more accurately determined from a few nights' observations with his new method than from years of meridian observations.

In conclusion, I can only allude in the briefest terms to the other important researches for which astronomers are indebted to M. Lœwy. The following is a summary of the other new methods of instrumental research which M. Lœwy has devised in the last few years:—

(1) A method for determining the flexure of transit-circles at various zenith distances by means of an optical apparatus inserted in the central cube. This has been used to find the flexure of two transit-circles at the Paris Observatory, the absolute values of the flexure for the two ends of the telescope and for the axis being independently determined.

(2) A method for obtaining the latitude without making use of the declinations of fundamental stars.

(3) A general method for determining right ascensions without relying on assumed right ascensions of polar stars.

(4) A method for finding on each night the absolute declinations of stars without the necessity for observations of polar stars at upper and lower transit.

(5) Methods for determining directly the two co-ordinates of polar stars without a previous investigation of the instrumental errors.

All these methods except the first are based on the observation of close circumpolar stars in R.A. and N.P.D. out of the meridian at various points of the circles described by them. Conjugate observations either of a single star or of a pair of stars having the same N.P.D. are made with a transit-circle, having a field of view of 2°, at equal intervals (about two hours) before and after meridian passage or before and after passage over the hour-circle of 6h. east or west. The special methods of observation are developed in a series of communications to the French Académie des Sciences made in the years 1883 and 1885, and during the last two years M. Rénan has applied these new methods to a determination of the latitude of the Paris Observatory based on eighty very accurate results.

The account which I have given of M. Lœwy's inventions and researches is necessarily very imperfect, and I have had to pass over many points of interest in the application of his methods. But I trust that the summary I have made will at any rate suffice to show the very high importance of M. Lœwy's labours, and that they fully deserve the recognition which is to-day given to them, whether we have regard to the originality of the methods or to the value of the results which are to be obtained from them.

STRUCTURE, ORIGIN, AND DISTRIBUTION OF CORAL REEFS AND ISLANDS.[1]

THE picturesque beauty of the coral atoll, seated 'mid a waste of troubled waters, with its circlet of living green, its quiet, placid lagoon, and its marvellous submarine zoological gardens, has long been celebrated in the descriptions of voyagers to tropical seas. The attempt to arrive at a correct explanation of the general and characteristic form and features of these reefs and islands has, for an equally long period of time, exercised the ingenuity of thoughtfulmen.

Coral reefs are the most gigantic and remarkable organic accumulations on the face of the earth. They are met with in certain tropical regions, and are huge masses of carbonate of lime, secreted from ocean waters by myriads of marine organisms. While the great bulk of the reef consists of dead corals, skeletons, and shells, the outer surface is clothed with a living mantle of plants and animals. This is especially the case on the outer and seaward face of the reef, where there are, at all times, myriads upon myriads of outstretched and hungry mouths, and not the least interesting questions connected with a coral reef are those relating to how these hungry mouths are satisfied.

It is to the power of these organisms of secreting carbonate of lime from sea-water—building up and out generation after generation on their dead selves—that the coral reef owes its origin. So wonderful and unique is the result, that combination for a definite end has sometimes been attributed to these reef-builders.

There is, however, another process ever at work in the ocean, in a sense antagonistic to that of secretion of carbonate of lime by organisms, which has much to do in fashioning the more characteristic features of coral reefs. This is the solution of all dead carbonate of lime shells, skeletons, and calcareous *débris*, wherever these are exposed to the action of sea-water. As soon as life loses its hold on the coral structures, and wherever these dead carbonate of lime remains are unprotected by rapid accumulation or crystalline depositions, they are silently, surely, and steadily removed in solution. This appears to be one of the best established oceanographical facts, and any theories concerning the general economy of the ocean which fail to take account of this universal agency are most likely to be at fault. We know something about the rate of solution, probably more than we do about the rate of growth and secretion of carbonate of lime by the coral Polyps. It has been shown that the rate of solution varies with temperature, with pressure, and with the amount of carbonic acid present in the water. It is on the play of these two opposing forces—the one vital and the other chemical—and their varying activity in different regions and under different circumstances, that we rely for the explanation of many oceanographical phenomena, especially many of those connected with oceanic deposits and coral reefs. In some regions there may be more growth, secretion, and deposition of shell and coral materials than solution

[1] Lecture delivered by Dr. John Murray at the Royal Institution on Friday, March 16, 1888. Recently revised by the Author.

by sea-water, and then there results the formation of coral reefs and vast calcareous deposits at the bottom of the ocean. There may be an almost exact balance between these processes. And again, there may be more solution than secretion, as, for instance, in the red clay areas, which occupy the deepest parts of the ocean, and in some coral-reef lagoons.

What is the nature of the foundations of these coral islands, surrounded as they sometimes are by an ocean miles in depth? Why have some elongated reefs no lagoons? Why have most of the lagoons of the smaller atolls been filled up? Why is the circle of land or reef in the perfect atolls only, at most, a few hundred yards in diameter? What is the origin of the lagoon? What relation exists between the depth of the lagoon, its area, and the depth of the water beyond the outer reef? How has the dry land of these islands been formed, provided with a soil, a fauna and a flora? These appear to be the chief questions that demand an answer from any theory of coral island formation.

These coral formations are essentially structures belonging to the great oceans and ocean basins. They are dots of land within the oceanic areas that might be compared or contrasted with the small salt lakes which are scattered over the surface of the continental lands. A rapid survey of some of the more general phenomena of the great oceans may, then, lead to a better appreciation of the problems connected with coral reefs.

The great ocean basins occupy over two-thirds of the earth's surface, and have a mean depth of over two miles. The central portions of these basins, called the abysmal regions, occupy about one-half of the earth's surface, and have a mean depression below the general level of the continents of over three miles. The abysmal regions are vast undulating plains, sometimes rising to less than two miles from the surface of the sea, and again sinking to four and five miles beneath it. Volcanic cones rise singly or in clusters from these great submerged plains. When they shoot above the level of the sea they form single islands, like Ascension and St. Paul's Rocks, or groups, like the Azores, the Sandwich, the Fiji, and the Society Islands. As might have been expected, there are many more of these cones hidden beneath the waves than rise above them. When the *Challenger* sounded along the west coast of Africa, there was no suspicion that between her stations she was sailing over submerged cones. Since then, however, the soundings of telegraph ships have correctly mapped out no less than seven of these peaks between the latitude of Lisbon and the Island of Teneriffe. The depths on the summits of these vary from 12 to 500 fathoms. On one of them, at 400 fathoms, two species of coral (*Lophohelia prolifera* and *Amphihelia oculata*) were growing luxuriantly. Throughout the ocean basins about 300 such submarine cones, rising from great depths up to within depths of from 500 to 10 fathoms from the surface, are already known, or indicated by soundings.

All the physical agencies at work above the lower limit of wave action tend to wear away and level down these cones, and thus to form banks. Graham's Island, thrown up in the Mediterranean in 1831, was 200 feet in height and three miles in circumference, and was washed away in a year or two. The bank left on the spot, at first very shallow, has now 24 feet of water over it. Instances similar to this historical example must often have happened in the great ocean basins. Again, the same agencies produce wide banks around volcanic islands by washing away and spreading out the materials of the softer rocks. Such banks, with depths of less than 60 fathoms, are found extending many miles seawards around some volcanic islands.

On the other hand, all the deeply submerged summits are continually being built up to the lower limit of wave action by the accumulation of the remains of animals which live on them and by the fall of shells upon them from the surface waters. In the Solomon Islands, Dr. Brougham Guppy has shown that there are upraised coral islands with central volcanic cones covered with thick layers of marine deposits; Christmas Island, in the Indian Ocean, is another instance, and similar deposits must now be forming over hundreds of submerged mountains. In this way are foundations prepared for the true reef-building species, which only flourish in the shallower depths.

The bulk of the water of the ocean has a very low temperature; it is ice-cold at the bottom, even under the equator, but on the surface within the tropics there is a relatively thin film of warm water, with a temperature of from 70° to 84° F. This film of warm water is much deeper towards the western parts of the Atlantic and Pacific than it is in the eastern, the reason for this being that the trade winds, which blow continually from the east, carry all the warm surface water to the westward, and draw up cold water from beneath along the western shores of Africa and America to supply the place of that driven westward at the surface. Consequently, there is, at times, a very low temperature, and a great annual range of temperature, along these western shores. This is more clearly shown by the temperatures at 50 and 100 fathoms than by those at the surface. There are no coral reefs along the western shores of Africa and South America, a circumstance evidently connected with the low temperature, wide range, and, more directly, with the food supply, consequent on these conditions. It appears to be a confirmation of this view that, on the eastern shores of Africa, about Cape Guardafui, from off which the south-west monsoon blows for several months in the year, cold water is also drawn to the surface, and there, likewise, are no coral reefs, though they flourish to the north and south of this region.

Coral reefs flourish in mid-ocean and along the eastern shores of the continents, or wherever the coasts are bathed by the warmest and purest currents of water coming directly from the open sea. If we except Bermuda and one or two other outlying reefs, where the temperature may occasionally fall to 66° or 64° F., it may be said that reefs are never found where the surface temperature of the water, at any time of the year, sinks below 70° F., and where the annual range is greater than 12° F. In typical coral reef regions, however, the temperature is higher and the range much less.

The food supply of the coral reef is derived from pelagic oceanic organisms, which exist in the greatest variety and abundance in the surface and sub-surface waters of the ocean. These consist of myriads of Algæ, Rhizopods, Infusorians, Medusæ, Annelids, Molluscs, Crustaceans, Ascidians, and fishes. A very large number of these creatures, within the tropics, secrete carbonate of lime from the ocean to form their shells and skeletons, which, falling to the bottom after death, form the vast oceanic deposits known as Pteropod and Globigerina oozes. In falling to the bottom, they carry down some of the organic matter that composed their living bodies, and thus are the animals which live on the floor of the ocean chiefly supplied with food. Here it may be remarked, incidentally, that the abundance of life at depths of even over two miles is very great. Our small dredges sometimes bring up over sixty species and hundreds of specimens in one haul—of invertebrates and fishes, exclusive of the Protozoa. The pelagic organisms above mentioned oscillate from the surface down to about 80 or 100 fathoms, probably that stratum of the ocean affected by sunlight, and they apparently descend further in regions where the stratum of warm water has a greater depth. Many of the forms rise to the surface in the evening and during calms, and sink again in sunlight and during stormy weather. It is in the evening and when it is calm that this swarming life is most vividly forced on the attention by gorgeous phosphorescent displays. The lime-secreting organisms, like Coccospheres and Rhabdospheres, Foraminifera, Pteropods, and other Molluscs, are much more abundant, both in species and individuals, in the warmest and saltest waters than elsewhere. I have estimated, from tow-net experiments, that at least 16 tons of carbonate of lime, in the form of these shells, exist in a mass of the ocean, in coral-reef regions, one mile square by 100 fathoms in depth. If we take this estimate, which I consider much below the reality, and suppose one-sixteenth of these organisms to die and fall to the bottom each day, then they would take between 400 and 500 years to form a deposit one inch in thickness. I give this calculation more to indicate a method than to give even the roughest approximation to a rate of accumulation of deposits. The experiments were too few to warrant any definite deductions.

The great oceanic currents, moving westward at the rate of several miles an hour, bear these shoals of pelagic organisms on to the face of the reef, where millions of greedy mouths are ready and eager to receive them. The corals and other organisms situated on the outer and windward side of the reef receive the first and best supply; they are thus endowed with a greater amount of energy, and grow faster and more luxuriantly there than on other portions of the reef. The depth at which there is the most constant supply of this food is several fathoms beneath the surface, and there, too, the corals are found in most vigorous growth. It is only a relatively small quantity of this pelagic food that enters the lagoon, the corals that there struggle on in patches being largely supplied with the means of existence from the larvæ of reef-building animals.

So many observations were made during the *Challenger* Expedition on the pelagic fauna inside and outside reefs that there is little, if any, doubt in my mind that the food supply is a most important factor in relation to the growth of corals in the different portions of a reef. Actual observations were made on the feeding of corals at a good many places, as well as numerous observations on the stomach contents. These observations have been confirmed by Alexander Agassiz.

It is as yet impossible to state in what form the lime, which is secreted as carbonate in such enormous quantities by marine organisms exists in the ocean.

Dana, in "Coral and Coral Islands," considers it "unnecessary to inquire whether the lime in sea-water exists as carbonate or sulphate, or whether chloride of calcium takes the place of these. The powers of life may take from the element present whatever results the function of the animal requires."

In connection with this question an interesting series of experiments are being conducted at the Scottish Marine Station, Granton, which go far to prove that the above hypothesis is correct.

The following table shows the average composition of sea-water salts, the acids and bases being combined in the way usually adopted by chemists—

Average Composition of Sea-Salt.

Chloride of sodium	77·758
Chloride of magnesium	10·878
Sulphate of magnesium	4·737
Sulphate of lime	3·600
Sulphate of potash	2·465
Bromide of magnesium	0·217
Carbonate of lime	0·345
	100·000

In the actual ocean water there are probably traces of every known element, and it is impossible to say what is the precise amount of the respective chlorides, sulphates, and carbonates present. Theoretically, every base may be combined with every acid, and the whole solution must be in a continual state of flux as to its internal composition. While the quantity of sea-salts in a given volume of water varies with position, yet it has been shown by hundreds of analyses that the actual ratio of acids and bases—that is, the ratio of the constituents of sea-salts—is constant in waters from all regions and depths, with one very significant exception—that of lime—which is present in slightly greater proportion in deep water.

The total amount of *calcium* in a cubic mile of sea-water is estimated at nearly 2,000,000 tons. The amount of the same element present in a cubic mile of river-water is nearly 150,000 tons. At the rate at which rivers carry down water from the land it is estimated that it would take 680,000 years to pour into the ocean an amount of calcium equal to that now held by the ocean in solution.

The amount of calcium existing in the 40,000,000 square miles of the typical calcareous deposits of the ocean exceeds, however, that at present held in solution if we merely take them to have an average thickness of 30 feet, and from this calculation we might say that, if the secretion and solution of lime in the other regions of the ocean be exactly balanced, and the calcium in the ocean remain always constant, those calcareous deposits of the thickness indicated would require between 600,000 and 700,000 years to accumulate. There is good evidence, however, that the rate of accumulation is much more rapid in some positions.

The lime thus carried down to the sea is originally derived from the decomposition of anhydrous minerals, and comes from the land in the form of carbonate, phosphate, and sulphate of lime—the carbonate being in the greatest abundance in river-water. On the other hand, the sulphate of lime very greatly predominates in sea-water, the carbonates being present in small quantity. We are not in a position to say whether or not the coral Polyps take the whole of the material for their skeletons from the carbonates, as is generally believed, or indeed to say what changes take place during the progress of secretion by organisms.

In the greatest depths of the Pacific coral seas there is striking evidence of the solvent power of ocean water. Our dredges bring up from a depth of three or four miles over a hundred ear-bones of whales and remnants of the dense Ziphioid beaks, but all the larger and more areolar bones of these immense animals have been almost entirely removed by solution. In a single haul there may also be many hundreds of sharks' teeth, some of them larger than the fossil *Carcharodon* teeth, but all that remains of them is the hard dentine. None of the numerous calcareous surface shells reach the bottom, although they are quite as abundant over the red clay areas as over those shallower areas, where they form Globigerina and Pteropod deposits. In consequence of the small amount of detrital material reaching these abysmal areas distant from continents, cosmic metallic spherules, manganese nodules, highly altered volcanic fragments, and zeolitic minerals, are there found in great numbers. Almost all these things are found occasionally in the other regions of the ocean's bed, but their presence is generally masked by the accumulation of other matters. In some regions Radiolarian and Diatom remains are found in the greatest depths, and they too are subject to the solvent power of sea-water, but to a much less extent than carbonate of lime shells.

As we ascend to shallower waters, a few fragments of the thicker-shelled specimens are met with at first; with lesser depths the carbonate of lime shells increase in number, until in the shallower deposits the remains of Pteropods, Heteropods, and the most delicate larval shells are present in the deposit at the bottom. This gradation in the appearance of the shells can be well seen in a series of soundings at different depths around a volcanic cone, such as has been described as forming the base of a coral atoll. There is no known way of accounting for this vertical distribution of these dead shells except by admitting that they have been dissolved away in sinking through the deeper strata of water, or shortly after reaching the bottom; indeed, an examination of the shells themselves almost shows the process in operation. It is rare to find any trace of fish-bones in deposits other than the otoliths.

These considerations, as well as numerous experiments in the laboratory, show that everywhere in the ocean dead or amorphous carbonate of lime structures quickly disappear wherever they are exposed to the action of sea-water, and in investigating the evolution of the general features of coral reefs it is as necessary to take cognizance of this fact as of the secretion of carbonate of lime by organisms. At the same time, too much stress cannot be laid upon the fact that carbonate of lime, although markedly soluble in sea-water in the amorphous form in which it exists in connection with (organic) life, becomes practically insoluble when after the death of the secreting animal it assumes the crystalline state.

In a paper read before the Royal Society of Edinburgh, embodying some of the results of his investigations on the solubility of carbonate of lime under different forms in sea-water, Mr. Irvine remarks, "It is due to this molecular change that coral deposits, shells, and calcareous plants are able to accumulate in the ocean, ultimately to form beds of limestone rocks."

The first stage, then, in the history of a coral island is the preparation of a suitable foundation on the submerged volcanic cones, or along the shores of a volcanic island, or the borders of a continent. In the case of the atoll the cone may have been reduced below the level of the sea by the waves and atmospheric influences, or built up to the lower limit of breaker action by the vast accumulation of organisms on its summit.

A time comes, however, should the peak be situated in a region where the temperature is sufficiently high, and the surface currents contain a suitable quality of food, that the reef-builders fix themselves on the bank. The massive structure which they secrete from ocean water enables them to build up and maintain their position in the very face of ocean currents, of breakers, of the overwhelming and outrageous sea.[1]

"Coral" with the sailor or marine surveyor is usually any carbonate of lime shell or skeleton or their broken-down parts. "Coral" is used by the naturalist in a much more restricted sense: he limits the term to animals classed as Madrepores, Hydrocorallines, and Alcyonarians. The animals belonging to the first two of these orders comprise those included under the vague term of reef corals. Besides these, however, very many other classes of animals contribute to the building up of coral

[1] Dr. Brougham Guppy says, "History can afford us no clue to the first appearance or the age of reefs; yet in the myths of the Pacific Islanders we find that the savage inhabitants of these regions regard the history of a coral atoll as commencing with the submerged shoal, which through the agency of God-like heroes is brought up by their fish-hooks to the surface." —Paper, Vict. Inst.

reefs and islands—such are Foraminifera, Sponges, Polyzoa, Annelids, Echinoderms, and Calcareous Algæ. The relative proportions of these different organisms in a reef vary with the region, with the depth, and with the temperature, but members of what are known under the term of reef corals appear always to predominate.

The animals of the true reef-building species resemble the common sea-anemones in structure and size; the individual Polyps may vary from the eighth of an inch in diameter to over a foot. Some of the structures built by colonies may exceed 20 feet in diameter.

There may be great variety in the appearance of submerged reefs as they rise from banks of a different nature, form, and extent, as, indeed, was pointed out long ago by Chamisso. There may be differences due also to the kinds and abundance of deep-sea animals living on such banks, as well as differences due to currents, temperature, and other meteorological conditions.

From the very first the plantations situated on the outer edge will have the advantage, from the more abundant supply of food and the absence of sand in the water, which last more or less injuriously affects those placed towards the interior. Chamisso attributed the existence of the lagoon to the more vigorous growth of the peripherally situated corals of a reef, as compared with those placed towards the middle, and in this he was to a large extent right, but the symmetrical form of the completed atoll is chiefly due to the solution of the dead carbonate of lime structures. The Great Chagos Bank illustrates the irregular way in which such a large bank of coral plantations approaches the surface. When these, however, reach the surface, they assume slowly a more regular outline, those on the outer edge coalesce, and ultimately form a complete ring of coral reef, and the lagoon becomes gradually cleared of its coral patches or islands, for, as the atoll becomes more perfect, the conditions of life within the lagoon become less and less favourable, and a larger quantity of dead coral is removed in solution.

The coral atoll varies greatly in size and form: it is usually more or less circular, horse-shoe shaped, and may be one or over fifty miles in diameter. The breakers spend their fury on the outer edge, and produce what is known as the broad shore platform; but within, trees descend to the very shore of the lagoon, where there is quiet water, and a ship may often enter on the lee side of the atoll and find safe anchorage.

In this connection it is important to bear in mind the relation which exists between the periphery and the superficial area of the lagoon in atolls of different sizes. If the coral plantations which rise from the top of a submerged mountain have an area of one square mile, then on reaching the surface of the waves there will be a shallow depression in the centre owing to the more rapid growth of the outer edge. Such an atoll will have, if it be a square, four miles of outer reef for the supply of coral sand and other *débris*, and these being washed and blown into the one square mile of shallow lagoon it is likely to become filled up, the result being a small island with dry lagoon, in which may be found deposits of sulphate of lime, magnesian and phosphatic rocks, and guano—all these testifying to the great age of the island and absence of subsidence in the region. It is only atolls with a diameter of less than two miles that thus become filled up. In other and larger plantations, rising from a more extensive bank, the conditions are very different. In this larger atoll—say four miles square—there is now only one mile of outer reef to each square mile of lagoon, instead of four miles of outer reef to the one square mile of lagoon in the smaller atoll. Only one-fourth of the detrital matter and food enters the larger lagoon, from the outside, per square mile of lagoon, and hence there is proportionately less living coral, the solvent agencies predominate, and the lagoon is widened and deepened. Growing seawards on the outer face and dissolving away in the lagoon, the whole expands after the manner of a fairy ring, and the ribbon of reef or land can never in consequence increase beyond a half or three-quarters of a mile in width, it being usually much less. I have recently made a very careful comparison of the latest Admiralty Survey of the lagoon of Diego Garcia with the one made many years ago, and the result appears to me to indicate that the area of the lagoon has considerably increased in the interval, and the average depth is a little greater than formerly, although shallower in some places.

Atolls may occur far away from any other land, but it more frequently happens that they are arranged in linear groups, in this respect resembling volcanic islands. Extensive banks may be crowded with small atolls, like the Northern Maldives; or a bank may be occupied by one great and perfect atoll twenty to forty miles in diameter, like some of the Southern Maldives and the Paumotus. In some instances the large atolls appear to have resulted from the growth and coalescence of the smaller marginal atolls; especially does this seem to have been the case with the large Southern Maldives.

The outer slopes vary greatly in different reefs, and in different parts of the same reef. When there is deep water beyond, the reef very often extends out with a gentle slope to a depth of 25 to 40 fathoms, and is studded with living coral, the bosses and knobs becoming larger in the deeper water farthest from the reef, where there are great overhanging cliffs, which eventually fall away by their own weight, and form a talus on which the reef may proceed further outwards. Occasionally there is a very steep descent almost at once from the outer edge. Thus, the deeper the water beyond, the more slowly will the reef extend seawards. In reefs with a very gentle slope outside, the corals are frequently overhanging at depths of 6 or 7 fathoms, for in these instances the lower part of the sea-face of the reef is rendered unsuitable for vigorous growth, in consequence of the sand which is carried in by waves coming over the comparatively shallow depths outside; in these cases, lines of growing corals, or a submerged barrier, are sometimes met with in deep water some distance seawards from the edge of the reef.

As has been stated, the lagoon in many of the smallest atolls has been filled up, but this never appears to happen in atolls with a diameter of over two miles unless there be distinct evidence of upheaval. In perfectly-formed atolls—that is, those in which the reefs are nearly continuous throughout—the deepest water is found towards the centre of the lagoon, and there is a relation between this depth and the depth of water beyond the outside reefs. In North and South Minerva reefs, in the South Pacific, where the outside depths are very great, there are depths down to 17 fathoms in the lagoons, which are apparently clear of coral heads. Here we may suppose that the central parts of the lagoon have for a long time been exposed to the solvent action of sea-water, owing to the slow lateral growth of the reef as a whole. In the same regions the Elizabeth and Middleton reefs, which are about the same size, have only 4 or 5 fathoms within the lagoons, and the depths outside the reefs are, at the distance of a mile, mostly within the 100-fathom line, and sometimes less than 50 fathoms. There are also many coral heads within the lagoons. Here we may suppose the atolls to be more recent, and to have extended more rapidly than in the case of the Minerva reefs. If the depths beyond the reefs be taken into consideration, then there is usually a direct relation between the depth of the lagoon and its diameter. The greatest depths, even in the largest atolls, do not exceed 50, or at most 60, fathoms; they are usually much less. In atolls which are deeply submerged, or have not yet reached the surface, which have wide and deep openings into lagoon-like spaces, this relation may not exist. In these instances the secretion and deposition of carbonate of lime may be in excess of solution in all parts of the lagoon. It is only when the atoll reaches the surface, becomes more perfect, and its lagoon waters consequently less favourable to growth, that the solution of the dead corals and calcareous *débris* exceeds any secretion and deposition that may take place throughout the whole extent of the lagoon; it is then widened and deepened, and formed into a more or less perfect cup-like depression, unless the lagoon be of small size and is filled up.

The whole of a coral reef is permeated with sea-water like a sponge; as this water is but slowly changed in the interior parts, it becomes saturated, and a deposition of crystalline carbonate of lime frequently takes place in the interstices of the corals and coral *débris*. In consequence of the solution of coral *débris* and the re-deposited lime occupying less space, large cavities are formed, and this process often results in local depressions in some islands, as, for instance, in Bermuda. At many points on a reef where evaporation takes place there is a deposition of amorphous carbonate of lime cementing the whole reef materials into a compact conglomerate-like rock.

The fragments of the various organisms broken off from the outer edge during gales or storms are piled up on the upper surface of the reef, and eventually ground into sand, the result being the formation of a sandy cay or shoal at some distance back from the outer edge of the reef—the first stage in the formation of dry land.

The fragments of pumice thrown up into the ocean during far-distant submarine eruptions, or washed down from volcanic lands, are at all times to be found floating about on the surface of the sea, and these, being cast up on the newly-formed islet, produce, by their disintegration, the clayey materials for the formation of a soil—the red earth of coral islands. Just within the shore platform these pumice fragments are found in a fresh condition, but as the lagoon is approached they disappear, the soil becomes deeper, and the most luxuriant vegetation and largest trees are found close to the edge of the inner waters. The land is seldom continuous around the atoll; it occurs usually in patches. The water passes over the shallow spaces between the islets and through the deeper lagoon entrances, these last being kept open by the strong sand-bearing currents which pass at each tide.

The few species of plants and animals which inhabit these coral islands have been drifted to the new island like the pumice, or carried, many of them maybe, by birds; lastly, savage and civilized man finds there a home.

There is no essential difference between the reefs forming fringing and barrier reefs, and those which are known as atolls. In the former case, the corals have commenced to grow close to the shore, and as they grow outward, a small boat-passage, and then a ship-channel, is carved out between the reef and the shore by tidal scour and the solvent action of the water on the dead parts of the reef: thus, the fringing reef may be converted into a barrier reef; or the barrier may be formed directly by the upward growth of the corals at some distance from the shore. In some instances the corals find a suitable foundation on the banks that surround islands and front continental lands, it may be, at a great distance from the coast, and when they reach the surface they form a distant barrier, which proceeds seawards, ultimately on a talus made up of materials torn from its seaward face.

If the foregoing considerations be just and tenable, then it would appear that all the characteristic features of coral reefs can be produced, alike in stationary areas or in areas of slow elevation and subsidence, by processes continually at work in the ocean at the present time. Slow elevation or subsidence would only modify in a minor way a typical coral atoll or barrier reef, but subsidence in past times cannot be regarded as the cause of the leading characteristics of coral reefs. There are abundant evidences of elevation in coral-reef regions in recent times, but no direct evidence of subsidence. If it has been shown that atoll and barrier reefs can be formed without subsidence, then it is most unlikely that their presence in any way indicates regions of the earth's surface where there have been wide, general, and slow depressions.

According to Mr. Darwin's theory, which has been almost universally accepted during the past half-century, the corals commence to grow close to the shore of an island or continent: as the land slowly sinks, the corals meanwhile grow upwards to the surface of the sea, and a water space—the lagoon channel—is formed between the shore of the island and the encircling reef, the fringing being thus converted into a barrier reef. Eventually, the central island sinks altogether from sight, and the barrier reef is converted into an atoll, the lagoon marking the place where the volcanic or other land once existed. Encircling reefs and atolls are represented as becoming smaller and smaller as the sinking goes on, and the final stage of the atoll is a small coral islet, less than two miles in diameter, with the lagoon filled up and covered with deposits of sea-salts and guano.

It is at once evident that the views now advocated are in almost all respects the reverse of those demanded by Mr. Darwin's theory.

The recent deep-sea investigations do not appear in any way to support the view that large or small islands once filled the spaces now occupied by the lagoon waters, and that the reefs show approximately the position of the shores of a subsided island. The structure of the upraised coral islands, so far as yet examined, appears to lend no support to the Darwinian theory of formation. When we remember that the great growing surface of existing reefs is the seaward face from the sea surface down to 20 or 40 fathoms, that large quantities of coral *débris* must be annually removed from lagoons in suspension and solution, that reefs expand laterally and remain always but a few hundred yards in width, that the lagoons of finished atolls are deepest in the centre, and are relatively shallow compared with the depth of the outer reefs, then it seems impossible, with our present knowledge, to admit that atolls or barrier reefs have ever been developed after the manner indicated by Mr. Darwin's simple and beautiful theory of coral reefs.

DARWIN VERSUS LAMARCK.[1]

AFTER a brief sketch of the life of Lamarck (1744–1829), his theory was stated in his own words as follows:—

"(1) In every animal which has not arrived at maturity, the increased and continued employment of any organ strengthens that organ gradually, develops it, enlarges it, and gives it a power proportional to the duration of its employment: on the other hand, the continued disuse of any organ gradually weakens it, deteriorates it, progressively diminishes its faculties, and finally causes it to disappear.

"(2) Every feature which, under natural conditions, individuals have gained or lost by the action of circumstances to which their race has been for some time exposed—as, for instance, the results of excessive use or disuse of an organ—is preserved in reproduction and transmitted to the offspring, provided that the acquired changes were present in both parents."

The small changes thus produced and transmitted from generation to generation are increased in successive generations by the action of the same causes which originated them, and thus in long periods of time the form and structure of the descendants of an ancestral organism may be completely changed as compared with the form and structure of the ancestor.

Given sufficient time, these small changes can have produced man and the higher animals from simple primitive protoplasmic animalcules.

Prof. Lankester then pointed out the truth of the first law of Lamarck, but mentioned the preliminary objections to Lamarck's theory, which had prevented its acceptance by the naturalists of the first half of this century. He then briefly epitomized Darwin's theory as follows:—

(1) All plants and animals produce offspring which resemble their parents on the whole (heredity); these offspring, however, exhibit also new and individual features differing from those of their parents (congenital variations).

(2) In Nature there is a severe struggle for existence. Only one pair out of the many thousands often produced by a pair of plants or animals survive to maturity, and in their turn produce offspring.

(3) The survivors are those whose congenital variations have enabled them to gain advantage over their fellows.

(4) The surviving forms *may* be almost exactly like their parents, but often a departure from the parental form must be an advantage, however small. Such departure, or variation, when IN-BORN or CONGENITAL, not only enables its possessor to survive and produce offspring, but is handed on by heredity to that offspring.

(5) A successful congenital variation is intensified in the new generation bred from parents in both of which it had congenitally appeared.

(6) By this process of natural selection of advantageous congenital variations, operating in countless millions of successive generations, the transformation of simple into more elaborate forms of life has been effected.

The real difference between Lamarck's and Darwin's theories was then explained. Congenital variation is an admitted and demonstrable fact; transmission of congenital variations is also an admitted and demonstrable fact. Change of structure acquired during life—as stated by Lamarck—is also a fact, though very limited. But the transmission of these latter changes to offspring is NOT PROVED EXPERIMENTALLY; all experiment tends to prove that they cannot be transmitted. Semper's book on this subject was cited as a failure in the attempt to prove such transmission.

The causes of congenital variations were next discussed, and the "stirring up" of the germ-plasma by the process of fertilization was pointed to as the chief.

Very minute congenital variations can be useful, and, therefore, selected; but congenital variations are not necessarily minute.

The subject of correlated variations was next mentioned, and their great importance pointed out. A mechanical model was used to explain this matter: it represented an antelope in which when the neck is made to elongate the legs simultaneously lengthen, whilst the horns disappear and the tail shortens.

The lecturer then gave examples of the successful explanation

[1] Abstract of a Lecture delivered at the London Institution, Finsbury Circus, on February 14, 1889, by Prof. Ray Lankester, LL.D., F.R.S.

of cases by Darwinism where Lamarckism fails. Mimicry and protective colouring, adaptation of flowers to insect visitors, instincts of neuter insects, and Lamarck's chosen case, the giraffe, were among these.

It was then pointed out that breeders have never produced new varieties by transmission of acquired characters (Lamarckian), but always by transmission of congenital characters (Darwinian).

Whilst all this tends to the complete rejection of Lamarck's theory, it is true that Darwin himself admitted Lamarckism as an explanation of some rudimentary organs (disuse), and of some instincts (transmission of acquired habit).

On the other hand, neo-Darwinians reject Lamarckism altogether, because (1) the fundamental fact of transmission of a change of structure or habit acquired during the life of an individual by the action of external agencies is not only not proved but is contrary to experience; (2) such transmission is highly improbable in view of the structure and origin of the reproductive germs; (3) even if admitted as possible, Lamarckism is not needed in order to explain the facts of the structure and habits of existing plants and animals, in addition to Darwinism. Pure Darwinism is sufficient.

Finally, the lecturer dealt with some cases advanced by Lamarckians as favourable to their views, and gave their Darwinian explanation.

Among these were rudimentary organs, where the fully-developed organ would not be injurious, *e.g.* the intrinsic muscles of the human ear. These were explained by panmixia and parsimony of growth.

Blind animals in caves and in the deep sea, *e.g.* blind crayfish, Thaumastocheles, and blind fishes, were shown to be best explained by the natural selection of congenital blindness. Amongst a whole brood of animals swept by a flood into a cavern, or by a current into deep water, those with perfect eyes would escape by following the light, whilst those with congenitally defective eyes would remain and reproduce their defect in their offspring, and in each succeeding generation the same process of natural selection would be continued.

Wingless insects and birds were similarly explained.

Instincts, *e.g.* "shamming dead," nest-building, choice of food, were briefly considered, and shown to be explicable by Darwinism and not by Lamarckism.

In fact, it was declared that, in proportion as our knowledge of any class of such facts is extensive and thorough, the Darwinian explanation is found to be correct and the Lamarckian inadequate and inapplicable.

A consideration of the mental evolution of man, according to neo-Darwinism was promised as the subject of a future lecture. It was briefly stated that the results of education and circumstances, good or bad, cannot be transmitted, whilst hereditary qualities, good or bad, cannot be eliminated, except by selection in breeding.

The transmission of acquired experience does not take place by heredity, but (among civilized societies) by the agency of tradition and books.

In civilized societies the injurious effects of unlimited neglect of selective breeding is largely neutralized by panmixia, giving an average race, neither wholly good nor wholly bad.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The Botanic Garden Syndicate, unlike some others at Cambridge, have been able to erect their new plant-houses within one pound of the estimate, £3000. The work has been satisfactorily done by Messrs. Boyd, of Paisley. Solid foundations have been laid, so that when required new wood-work may be built on the same walls. The new houses include a warm orchid-house, warm fern-house, stove, palm-house, aquarium, and stove-pit. A laboratory, for investigations required to be conducted near the plant-houses, has been built; it contains two large working-rooms and a dark chamber. The collections removed to the new houses are now in capital condition. The hardy cactuses, probably unsurpassed, have been removed to the border in front of the new stove. A new bed has been made for the choicer hardy Ericaceæ. Great progress has been made in naming and labelling. Among plants of scientific interest that have flowered in the gardens is *Pilocarpus pennatifolius*, which yields pilocarpine, *Erythroxylon Coca*, *Narcissus Broussoneti* (the corona a mere rim), and many others. Among the most interesting plants received have been *Gerbera Jamesoni*, a fine Composite from the Cape, *Isonandra Gutta* (yielding gutta-percha), *Washingtonia robusta*, a choice new palm, *Stachys tuberifera*, a new vegetable (the crosues of the Paris markets), and numerous hardy bamboos.

The regulations altering the arrangements of papers in the Natural Sciences Tripos have been confirmed, making the papers special ones in subjects, instead of general ones covering all the subjects.

The following have been appointed members of the Boards of Electors to Professorships named: Moral Philosophy, Principal Caird; Chemistry, Prof. A. W. Williamson; Botany, Sir Joseph Hooker; Geology, Prof. A. H. Green; Jacksonian of Natural Philosophy, Prof. A. W. Williamson; Mineralogy, Prof. H. N. Story-Maskelyne; Political Economy, Right Hon. L. H. Courtney; Zoology, W. H. Flower, C.B.; Experimental Physics, Sir W. R. Grove; Mechanism and Applied Mechanics, Sir F. J. Bramwell, F.R.S.; Physiology, Prof. Humphry; Logic, Prof. Bain.

Mr. A. E. Shipley has been approved as a teacher of Comparative Anatomy for the purpose of medical study.

SCIENTIFIC SERIALS.

The American Journal of Science, February.—Points in the geological history of the Islands Maui and Oahu, Hawaii, by James D. Dana. The subjects illustrated by the present state of these islands are: the conditions of extinct volcanoes in different stages of degradation; the origin of long lines of precipice cutting deeply through the mountains; the extent and condition of one of the largest of craters at the period of extinction, and the relation of cinder and tufa cones to the parent volcano. The accompanying plates, reduced from the recent large Government maps, show the present general features of both islands. Incidental reference is made to the late controversy on Darwin's theory of coral islands, the author declaring emphatically that no facts have hitherto been published by Mr. Murray or Mr. Guppy that prove the theory false, or set aside the arguments in its favour. Some of the facts are more in favour than opposed to it, while none do more than offer a possible alternative.—An experiment bearing upon the question of the direction and velocity of the electric current, by Edward L. Nichols and William S. Franklin. The authors, who had already independently developed a method similar to that lately described by Foeppl (*Annalen der Physik und Chemie*), here repeat his experiment with an apparatus capable of indicating the direction and velocity of the current, supposing it to have direction, even though that velocity were very great indeed. They show that they would have been able to detect a change of deflection due to the motion of the coil, even though the velocity of the current had been considerably in excess of one thousand million metres per second.—On the occurrence of monazite as an accessory element in rocks, by Orville A. Derby. The researches of Mr. John Gordon and Prof. Gorceix have placed beyond doubt the wide distribution of monazite in the sea and river sands of Brazil, but under circumstances that give no clue to its origin. The petrographic analyses here described have resulted in the discovery that gneiss, granite, and syenite yield, besides zircon, a certain quantity of microscopic crystals of a heavy yellow mineral apparently identical with the Bahia monazite. Recently, also, Mr. Gordon has obtained residues of zircon and monazite from the river sands at Buenos Ayres, and from gneiss and granite decomposed *in situ* at Cordoba in the Argentine Republic.—On the use of steam in spectrum analysis, by John Trowbridge and W. C. Sabine. These experiments show that a remarkable degree of economy in time and in waste of apparatus results from the use of a jet of steam in spectrum analysis, when the spark method of obtaining the spectra of metals is employed.—A comparison of the electric theory of light and Sir William Thomson's theory of a quasi-labile ether, by J. Willard Gibbs. A comparison is here instituted between the electric theory of light and the new theory of an elastic ether expounded by Sir William Thomson in the *Philosophical Magazine* for November 1888. The result of this inquiry seems to be that both theories in their extreme cases give identical results. The greater or less degree of elegance, or completeness, or perspicuity, with which these laws may be developed by different physicists should weigh nothing in favour of either theory. The elastic theory, however, is regarded as somewhat less convenient as a working hypothesis than the electric.—In this number appears Part I of an exhaustive monograph, with numerous illustrations, on the geology of the volcanic island of Fernando de Noronha, South-West Atlantic, by John C. Branner.

THE last volume (xviii.) of the *Memoirs of the Kazan Society of Naturalists* contains an elaborate inquiry into the distribution of solanin (an alkaloid discovered by Desfosses in many *Solanaceæ*) in plants, by E. Wotschall; short reports on geological exploration in the Governments of Vyatka and Ufa, by A. Netschaeff and A. Lavrsky; and a description of the flora of the neighbourhood of Ufa, by A. Gordyaghin.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 7.—"The Principles of Training Rivers through Tidal Estuaries, as illustrated by Investigations into the Methods of improving the Navigation Channels of the Estuary of the Seine." By Leveson Francis Vernon-Harcourt, M.A., M.Inst.C.E.

After stating the principles upon which the training of the non-tidal portions of rivers are carried out, the undefined and unsatisfactory condition of the principles followed in training rivers through wide tidal estuaries, and the discordant views of engineers on the subject, were pointed out. The absence of definite principles, and the divergence of opinion amongst engineers, have received a remarkable illustration in the great variety of schemes proposed for extending the training walls in the Seine estuary beyond Berville, where the works were stopped, in 1870, owing to the unexpected changes the works had already produced. It occurred to the author in August 1886, that if it should be possible to reproduce, in a working model, the original state of the Seine estuary before the training works were commenced, and next the present state of the Seine, as modified by these works, could be obtained, then the successive introduction in the model of the several schemes, proposed for the extension of the training walls, might furnish results indicating approximately in miniature the changes which the works would actually produce if carried out in the estuary, and also afford a basis for the establishment of general principles for training rivers through wide estuaries. A model, accordingly, was made of the tidal Seine, to the scale of 1/40,000 horizontal, and 1/400 vertical; the bed was formed of fine sand, so that it could be moulded by the current; the fresh-water discharge was produced, at the upper end, by the flow of water from a small cistern; and the tidal ebb and flow were effected by the tipping of a tray, placed at a suitable angle at the lower end, representing the open sea. The model was first worked in November 1886, and the experiments were continued at intervals up to 1889. Silver sand was first used for forming the bed of the miniature estuary; and some of the phenomena of the actual estuary, such as the *bore*, the "*verhaule*" or reverse current, and the shifting channels, were reproduced in the model; but when the training walls were introduced into the model, on the lines of the existing training walls, it was found that the silver sand could not be adequately carried in suspension by the small currents in the model to reproduce the accretion which has occurred in the estuary behind and beyond the training walls. A variety of fine powders, of low specific gravity, were consequently experimented on in the model, but they mostly proved too sticky, or pasty, or otherwise unsuitable. At last a fine sand from Chobham Common, belonging to the Bagshot beds, containing an admixture of peat, offered better results, and was employed for the subsequent experiments.

After working the model for some time with a bed formed of this Bagshot sand, the channels assumed a form very closely resembling in general outline the chart of the Seine of 1834. This result, by reproducing a former condition of the estuary, confirms the previous results obtained by Prof. Osborne Reynolds with a model of the Upper Mersey estuary, showing that it is quite practicable to reproduce in a model the main tidal channels in an estuary.

The second stage of the investigation involved the quite novel condition of introducing training walls in a model, and producing the resulting accretion. This most essential stage was the subject of a long series of experiments, but was at last satisfactorily accomplished with Bagshot sand. The existing training walls were inserted in the model, and the resulting deepening of the trained channel and the accretion outside and beyond were reproduced in the model, and also the shifting channel between the termination of the training walls and the sea.

The third stage of the investigation was then entered upon, consisting in the successive introduction in the model of the lines of the five principal schemes at present advocated, observing the changes they respectively produced in the model of the estuary, and recording them in the form of charts of the estuary, which are appended as plates to the paper. A final experiment was also made with an arrangement of training walls forming as gradually expanding a channel as practicable, without restricting the width of the outlet. The lines designed for the extension of the training walls in each scheme are briefly described in the paper, as well as indicated in the charts, and also the channels and accretion which they each produced.

The probability of the results obtained really representing in miniature the results which corresponding works in the estuary of the Seine would actually produce was then considered; for if the effects of any training works could be foreshadowed by experiments in a model, the value of such experiments, in guiding engineers towards the selection of the most suitable design, could not be over-estimated. Though the effects of winds and waves, and the actual rate of accretion, cannot be reproduced in a model, it is evident, from the first stage of the investigation, that the main forces at work, in the comparative shelter of an estuary, are the tidal ebb and flow and the fresh-water discharge, which are the forces which can be produced in a model. Moreover, the correspondence of the second stage of the investigation with the existing state of the Seine estuary confirms the accordance between the results in the model and the condition of the estuary. The extension of training walls decreases the influence of winds and waves; and therefore the results of the third stage of the investigation are more likely to correspond with the changes which such works would actually produce in the estuary, than those of the first and second stages. Also the results obtained in the model with the two earlier schemes are precisely those which the author predicted would occur, before the experiments were commenced, if the schemes were actually carried out in the estuary.

The paper concludes with a classification of the experiments, with the view of deducing general principles for guidance in training rivers through tidal estuaries. The three classes are, (1) outlet of estuary considerably restricted, and channel trained inside towards outlet; (2) channel trained in sinuous line, expanding towards outlet, but kept somewhat narrow at changes of curvature; (3) channel trained in as direct a course as practicable, and expanding regularly to outlet.

The experiments of the first class exhibited a deep outlet, and a fairly continuous channel inside where the training works were prolonged to the outlet. The channel, however, was irregular in depth near the outlet; and a bar appeared in front of the outlet outside. The breakwater, also, extending across part of the original outlet, occasioned deposits both inside and outside the estuary, by producing slack water in the sheltered recesses.

The second class of trained channel was designed to profit by the well-known scour at the concave face of bends in non-tidal rivers, and to continue the depth thus obtained by restricting the width between the bends. Experiment, however, did not bear out the advantages of this system, probably owing to the variable direction of the flood tide at different heights of tide, its being checked in its progress by the winding course, and not acting in unison with the ebb, from the difference in its direction and the width of the trained channel near the outlet. The third class of trained channel afforded a wide channel, tolerably uniform in depth, in the experiments; the flood tide was less impeded in its progress than with the other forms of training walls, and appeared to act more in concert with the ebb.

The experiments accordingly indicate that the only satisfactory principle for training rivers through wide estuaries with silt-bearing currents is to give the trained channel a gradually expanding form, with as direct a course as practicable to the outlet. The rate of increase in width between the training walls must be determined by the special conditions of the estuary.

February 14.—"On a Series of Salts of a Base containing Chromium and Urea," No. 2. By W. J. Sell and Prof. W. J. Lewis.

The paper is a continuation of that published by one of the authors (Proc. Roy. Soc., vol. xxxiii. p. 267). It is here shown that the chief product of the reaction of chromyl dichloride on urea is the dichlortetrachlorochromate of a base containing the elements of urea with chromium to which the formula $\left\{ (CON_2H_4)_{12}Cr_2 \left\} \begin{matrix} 4CrO_3Cl \\ Cl_2 \end{matrix} \right. \right.$ is assigned. This compound crystallizes from hydrochloric acid in brown-yellow crusts, which are immediately decomposed by water with formation of the dichlordichromate and hydrochloric acid. Among a large number of other new salts described, of which the normal bromide, $(CON_2H_4)_{12}Cr_2Br_66H_2O$, and iodide, $(CON_2H_4)_{12}Cr_2I_6$, may be taken as typical, the base also forms a perbromide, $(CON_2H_4)_{12}Cr_2Br_66Br_2$, and a periodide of similar composition, behaving in this respect like the organic bases. These substances, as indeed all the salts hitherto obtained, crystallize with great facility, and are as a rule sparingly soluble.

Anthropological Institute, February 12.—Dr. John Beddoe, F.R.S., President, in the chair.—Dr. Beddoe read a paper on human remains discovered by General Pitt-Rivers at Woodcuts, Rotherley, and Winkelbury Camp.—Mr. Bernard Hollander read a paper on centres of ideation in the brain. The object of this paper was to furnish the basis of a scientific phrenology. The author took it for granted: (1) that all mind manifestation is dependent on brain matter; (2) that the various elements of the mind have distinct seats in the brain, which, however, have not been as yet determined; (3) that the recent researches by physiological experimenters and pathological investigators, which have resulted in defining distinct regions for motion and sensation, established the physiological correlative of psychological actions. By applying galvanic currents to definite portions of the brain, or by destroying certain areas, physiological experimenters caused movements of certain limbs and muscles. In itself the distribution of motor areas in the brain would be of little value to the psychologist, except that it proves to him the plurality of functions of the brain. When, however, we observe that the movements caused by excitation form the physical parallel of a mental action, we may arrive at the psychological function of a certain portion of brain by reducing the various faculties of the mind to their elements, and watching their physical expression. To arrive at the demonstration of centres of ideation: (1) we must observe the physical expressions of our thoughts and feelings; (2) we must take the limbs and muscles, which are affected by definite emotions, and see on what occasions they are made to move by central excitation. Thus we find that in a definite part of the frontal convolution (Ferrier's centre No. 7) the galvanic current had the effect of elevating the cheeks and angles of the mouth with closure of the eyes. On no other region could the same be effected. Darwin points out ("Expression of the Emotions," p. 202) that under the emotion of joy the mouth is acted on exclusively by the great zygomatic muscles, which serve to draw the corners backwards and upwards. The upper and lower orbicular muscles are at the same time more or less contracted. Duchenne and Sir Chas. Bell are of the same opinion, and Sir Crichton Browne, speaking of the general paralysis of the insane, says that in this malady there is invariably optimism, delusions as to wealth, rank, &c., and insane joyousness, while its very earliest physical symptom is trembling at the corners of the mouth. The effect produced by the galvanic current on Ferrier's centre No. 7 is thus shown to be the physical expression of the emotion of joy. Combe located there his "organ of cheerfulness" which he afterwards called "Hope"; and there is no doubt some relation between the effect of Ferrier's experiment and the result of Combe's observation. Prof. Sigmund Exner says the centres for the facial movements extend from the gyrus centralis anterior to the latter halves of the lower frontal convolutions, an area which corresponds with Gall's "centre for mimicry" (afterwards named "Imitation.") Most marked, however, is the harmony between the results of modern experiments and the observations made by the early phrenologists when we arrive at the demonstration of the "gustatory centre." Ferrier's experiments on the lower extremity of the temporo-sphenoidal convolution caused movements of the lips, tongue, and cheeks—indications of gustatory sensation. Looking up the *Edinburgh Phrenological Journal* (vol. x. p. 249), we find that many men claimed the discovery (in 1824) of the organ for gustatory sensation, as afterwards called "Gustativeness" or "Alimentiveness," and that they located this centre in exactly the same region. As this organ is difficult to be observed on account of the zygomatic arch and the temporal muscle, phrenology was much abused at the time. Prof. Ferrier's experiments on his centre No. 11, on the lower extremity of the ascending parietal convolution, resulted in retraction of the angle of the mouth. The action is that of the platysma myoides muscle, which, as Sir Chas. Bell ("Anatomy of Expression," p. 168) states, is strongly contracted under the influence of fear, and which he calls the muscle of fright. Phrenologists (Gall and Spurzheim) located in this region their organ of "Cautiousness," which they found largely developed in persons known for their timidity. Prof. Ferrier's centre No. 7 is said to cause "raising of the shoulders with extension of the arms," a movement which Darwin and Mantegazza refer to the expression of patience, submission, and the absence of any intention to resist. Gall's organ of "Veneration," which corresponds with this centre, is said to produce an instinctive feeling of respect, and when defective in children, Combe says, it has the effect of making them regardless of authority, prone to rebellion, and little attentive to command. Though the work, as described, is far from complete, it may have the effect of causing Gall's theories to be re-examined, and of pointing out a sure method for the demonstration of centres of ideation.

Mathematical Society, February 14.—J. J. Walker, F.R.S., President, in the chair.—Mr. H. F. Baker was admitted into the Society.—The following communications were made:—On the diophantine equation $y^2 + \left(\frac{dy}{dx}\right)^2$ = square, Prof. Cayley, F.R.S.—Sur la transformation des équations algébriques, Signor Brioschi.—On projective cyclic concomitants or surface differential invariants, E. B. Elliott.—On secondary invariants, Prof. L. J. Rogers.—Remarks upon algebraical symmetry, with particular reference to the theory of operations and the theory of distributions, Major Macmahon.

Royal Meteorological Society, February 20.—Dr. W. Marcet, F.R.S., President, in the chair.—The following papers were read:—Report on the helm wind inquiry, by Mr. W. Marriott. The helm wind is peculiar to the Cross Fell Range of mountains in Cumberland, which runs from north-north-west to south-south-east. This range is high and continuous, and is not cut through by any valley. Cross Fell is 2900 feet above sea-level. From the top of the mountains to the plain on the west there is an abrupt fall of from 1000 to 1500 feet in about a mile and a half. At times when the wind is from some easterly point the helm forms over this district; the chief features of the phenomenon being the following: a heavy bank of cloud rests along the Cross Fell Range—at times reaching some distance down the western slopes, and at others hovering just above the summit; while at a distance of two or three miles from the foot of the Fell a slender roll of dark cloud appears in mid-air and parallel with the helm cloud; this is the helm bar. The space between the helm cloud and the bar is usually quite clear, while to the westward the sky is at times completely covered with cloud. The bar does not appear to extend further west than about the River Eden. A cold wind rushes down the sides of the Fell, and blows violently till it reaches a spot nearly underneath the helm bars when it suddenly ceases. The observations that have been made in the district during the past three or four years show that the helm wind is not such a rare occurrence as it was popularly supposed to be, the bar having been observed on forty-one occasions in 1885, sixty-three in 1886, and nineteen in 1887. The phenomenon takes place usually when the sky to the eastward is covered with cloud.—An atmospheric sketch, by Mr. F. A. Velschow.—The drought in New South Wales in 1883-84, and rainfall at Corella, 1879-88, by the Ven. Archdeacon Wynne.

Royal Microscopical Society, February 13.—Annual Meeting.—Dr. C. T. Hudson in the chair.—The Report of the Council was read, showing an increase in the number of Fellows, and in the revenue of the Society. This will probably be the last annual meeting in the present library, which is required by King's College, and the Society will have to seek a new habitation.—Dr. Hudson delivered his annual address, taking as his subject, "Rotifers and their Distribution."

PARIS.

Academy of Sciences, February 18.—M. Des Cloizeaux, President, in the chair.—On the vaccinal properties of pathogenic microbes transformed to simple saprogenic microbes destitute of all virulent properties, by M. A. Chauveau. These researches have been undertaken for the purpose of estimating the value of certain facts supposed to throw some light on the natural history of micro-organisms in general, with special reference to the question of specific transformation. The main conclusion is that the charbon microbe entirely deprived of its virulence has not become the simple saprogenic microbe of ordinary fermentations set up in inorganic centres, for it has still preserved one of the most essential attributes that indicate the infectious nature of the pathogenic microbe; hence it has not undergone specific transformation. Such at least is the present inference, without prejudice to the question of possible ulterior metamorphoses of which *Bacillus anthracis* may be capable under the action of compressed oxygen or any other means. In a future communication it will be shown that at this stage the microbe has not even been deprived of the faculty of reverting to its virulent state.—On Egyptian blue, by M. F. Fouqué. The author has undertaken a fresh study of this pigment, which was discovered by Vestorius, of Alexandria, but which ceased to be made after the fall of the Western Empire. He finds its formula to be $CaO,CuO,4SiO_2$, consisting of 63·7 parts of silica, 14·3 of lime, 21·3 of copper oxide, with a trace of iron; specific gravity 3·04.—On two fossil Echinodermata from Thersakhan in Turkestan, by M. G. Cotteau. These specimens from the banks of the Sumbar, an affluent of the Attrek, are identical with the *Coraster vilanovæ* which abounds in the Upper Chalk of Alicante, Spain. Their presence in Turkestan at such a distance from the Pyrenees shows that at one time the Cretaceous seas occupied vast regions stretching eastwards to Central Asia and India.—Summary of the solar observations made at the Royal Observatory of the Collegio Romano during the second half of the year 1888, by M. P. Tacchini. Compared with the corresponding period for 1887 and 1886, the solar spots show a further decline in 1888, with a maximum of days without any spots. The protuberances have also decreased, but more irregularly, and at a less rapid rate.—On shooting-stars, by M. E. Minary. It is argued that the incandescence of these bodies cannot be explained by the transformation of motion into heat. The gases being perfectly elastic bodies, and in the upper atmospheric regions in an extremely rarefied state, heat cannot be produced by the shock of bodies endowed with great velocity and impinging on perfectly elastic molecules capable of receiving the motion and acquiring the velocity of those bodies; in this case the movement is communicated, not dissipated or transformed to heat. Had such transformation taken place, the velocity of the bodies on their trajectory would be progressively retarded, while the incandescence would be proportionately increased. But observation shows only luminous flashes, and more or less uniform velocities of translation at least for all the bodies that are not combustible. The reading of the paper was followed by some observations by M. Cornu, who remarked that the illumination of the trajectory of the shooting-stars might be attributed to a development or a discharge of static electricity without any considerable rise of temperature; as implied by the incandescence of detached particles of meteorites. This would agree with the spectral observations made on the shooting-stars, and would lend support to the view that certain cosmic phenomena, such as auroras, the zodiacal light, comets, solar protuberances, &c., are electric manifestations analogous to those that are so easily generated in rarefied gases.—On a general law relative to the effects of reversible transformations, by M. Gouy. It has been noticed that the effects produced by mechanical actions are often opposed to those actions (law of Lenz, thermic effects). Here M. Gouy establishes a general law, of which these facts form a particular instance, and which is applicable not only to direct mechanical actions, but also to a large number of reversible transformations.—Experimental studies on the dynamic and static elasticity of metallic wires, by M. E. Mercadier. As a complement to various researches in acoustics and thermodynamics, the author here determines the velocity of sound in metallic wires, first by directly registering their longitudinal vibrations, and then by deducing the velocity from the measurement of elastic expansions. His researches extend to copper, steel, platinum, aluminium, silver, and gold wire, varying in diameter from 0·5 to 1 millimetre.—On the rotatory power of crystallized chlorate of soda, by M. Ch. Eug. Guye. The results of these experiments agree fairly well with those obtained by M. Schuke for the visible parts of the spectrum. They may easily be reduced to a uniform temperature by employing the coefficient given by that physicist. These studies will be continued for the purpose of ascertaining whether the same coefficient is equally applicable to the ultra-violet radiations.—Tests for the mercaptans, by M. G. Denigès. Isatine, already used in sulphuric solution as a test for thiophene, is here shown to be also an excellent test for mercaptan.—On the origin of the eruptive rocks, by M. A. de Lapparent. From the constitution of the acid rocks—that is, those charged with silica—a fresh argument is drawn in support of the theory respecting the primordial fluidity of the globe.—Papers are contributed by M. M. Meslans, on the preparation and properties of the fluorides of propyl and isopropyl; by M. A. Lacroix, on the petrography of gneiss occurring in Ceylon and in Salem (Madras); and by MM. G. Weiss and A. Erckmann, on the optical properties of natural and false amber.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Natural Inheritance: F. Galton (Macmillan).—Cactus Culture for Amateurs: W. Watson (U. Gill).—Key to Lock's Elementary Trigonometry: H. Carr (Macmillan).—Key to Lock's Trigonometry for Beginners (Macmillan).—On Truth: St. G. Mivart (K. Paul).—The History of Ancient Civilization: edited by Rev. J. Verschoyle (Chapman and Hall).—Galileo and his Judges: F. R. Wegg-Prosser (Chapman and Hall).—The Coleopterous Fauna of the Liverpool District: J. W. Ellis (Liverpool, Turner).—Prodromus of the Zoology of Victoria, Decade xvii.: F. McCoy (Melbourne, Brain).—Das Klima des Aussertropischen Südafrika: Dr. K. Dove (Göttingen).—Proceedings of the Royal Society of Edinburgh, Nos. 126 and 127 (Edinburgh).—Report of the Marlborough College Natural History Society for Year ending Christmas 1888 (Marlborough).—Logic: R. F. Clarke (Longmans).—Practical Organic Chemistry: S. Rideal (Lewis).—Elementary Synthetic Geometry: N. F. Dupuis (Macmillan).—The Mineral Wealth of Queensland: R. L. Jack (Brisbane).—Basic Slag: C. M. Aikman (Edinburgh).—The Practical Use of the Spectroscope: J. Parry.—Zeitschrift für Wissenschaftliche Zoologie, Band 31–45 (Williams and Norgate).—Proceedings of the Boston Society of Natural History, vol. xxiii. Parts 3 and 4 (Boston).—Annalen der Physik und Chemie, 1889, No. 3 (Leipzig, Barth).—Quarterly Journal of the Geological Society, No. 177 (Longmans).—Journal of the Bombay Natural History Society, No. 4, vol. iii. (Bombay).—Kryptogamen-Flora von Schlesien, 3 Band, 5 Liefg. (Breslau).—Tōkyō Sūgaku Butsurigaku Kwai Kiji, Maki No. 4, Dai 2.—Die Natürlichen Pflanzenfamilien, Liefg. 26, 27, 28 (Leipzig, Engelmann).

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