THURSDAY, AUGUST 24, 1899.

THE BOOK OF THE DEAD.

The Book of the Dead. Facsimiles of the Papyri of Hunefer, Ānhai, Ḳerāsher and Netchemet, with Supplementary Text from the Papyrus of Nu, with Transcripts, Translations, &c. By E. A. Wallis Budge, M.A., Litt.D., D.Lit., Keeper of the Egyptian and Assyrian Antiquities, British Museum. Pp. xi + 64 (fol.) + 98 plates. Printed by order of the Trustees. (London, 1899.)

SINCE the beginning of the present century the "Book of the Dead" has occupied the attention of the learned world, and has been a subject of study among all those who take an interest in the religious beliefs of the ancient races of mankind. The earliest publications on the subject took the form of somewhat inaccurate reproductions of papyri on which the text of the "Book of the Dead" was written; and, though much speculation existed as to the nature of its contents, it was not until well on in the present century that the foundations were laid for its correct interpretation. Champollion had made careful studies of the whole of the texts of the "Book of the Dead" to which he had access; and, from the translations of detached passages which are found scattered in his writings, it is clear that he recognised the general character of the composition. But he never translated a section of any length, and the fact that he termed the "Book of the Dead" "le Rituel Funéraire" of the Egyptians showed that he had not correctly grasped its aim and object. More than thirty years later De Rougé adopted Champollion's title for the work, but since that time it has come to be recognised by all that the composition is not a collection of ritual texts, and that a more general phrase such as "Book of the Dead" is a more suitable title for the work.

The title "Book of the Dead" may be traced to Lepsius, who in 1842, under the heading "Das Todtenbuch der Aegypter" published the text of a papyrus at Turin, which contained one hundred and sixty-five sections or chapters of the work. The ancient Egyptians themselves did not number these chapters, and no two papyri contain exactly the same chapters, nor are they always arranged in the same order. Lepsius, however, numbered the chapters as he found them in his papyrus, and though the text he published does not belong to the best period of the development of the "Book of the Dead," his numbering of the chapters has been retained in subsequent editions of the work. It was retained by M. Naville in his great work on the papyri of the eighteenth to the twentieth dynasties, which was published in 1886; and it has also been retained in the recent important publications issued by the Trustees of the British Museum.

In order to indicate clearly the importance of the volume before us, it will be necessary to give a brief account of what the "Book of the Dead" is. It consists of a collection of chapters or separate compositions of different lengths, which are found in Egypt inscribed upon pyramids, upon the walls of tombs, upon sarcophagi, and coffins, and amulets that were buried with the dead; it is also found written upon long rolls of papyri which were placed in the tomb with the deceased. Stated briefly, the object of all these compositions was to ensure the preservation of the dead man's body and to secure his welfare in the world beyond the grave. Dr. Wallis Budge has recently put forward a theory as to the process by which such powers became ascribed to this collection of compositions, which are conveniently classed together as the "Book of the Dead." He has pointed out that in the earliest period of Egyptian civilisation the dwellers on the Nile, as is evident from recent excavations, were in the habit of carefully preserving the dead bodies of their friends and relatives. Even at this early period it is clear that the Egyptian hoped to live a life after death, and that the life he looked forward to he imagined would be very similar to that he lived on earth; and it is also clear that to attain this future life he believed that it was absolutely necessary to preserve his body from decay. The earliest graves in Egypt show that the Egyptians of that period, like their descendants of later date, endeavoured to attain to the future life by the embalming of the body. The recently excavated prehistoric graves, in which, along with flints, bronze implements and pottery, the skeletons of human bodies have been found lying on their sides with their knees bent up on a level with the chest, furnish evidence that even at the dawn of history the inhabitants of Egypt embalmed their dead; for many of the bones found in the graves show traces that the bodies to which they belonged had been treated with substances used in embalming. But it was clear to the ancient Egyptian that bodies, even when embalmed, were accessible to the attacks of foes and to the ravages of wild beasts. And so, in course of time, men raised pyramids about the dead to protect them, or buried them in chambers hewn out of the living rock. But the most carefully constructed tomb could not wholly prevent decay, and there was always danger of damp getting to the tomb, or of the body falling to pieces from dry-rot. According to Dr. Budge's theory, the Egyptian now called in some other power besides his own to prevent the destruction of the body, and, while he still continued to embalm his dead, he assigned to the priest the task of finding some means by which decay might be prevented. To attain this end the priest pronounced certain words and formulæ over the body. These formulæ, Dr. Budge considers, formed the foundation of the "Book of the Dead" of later times. As was but natural, they gradually increased in number and complexity, and developed with the changing civilisation of the race; with them were incorporated beliefs belonging to various periods in the long course of Egyptian history, and opinions held by quite different schools of thought. But the object of all these various compositions was the same, namely, to benefit the deceased man beyond the grave. They were intended to give him all he would want in the future life, they would ensure him victory over his foes, and they would enable him to safely reach the abode of the blessed, where he hoped to live happily in the future.

The importance of a careful and comparative study of these numerous forms of the "Book of the Dead" for a right understanding of the religion of the ancient Egyptians is obvious, and the first step towards such a comparative study is to acquire all texts available for the purpose and to make them accessible to the numerous students, who in England, and on the continent, and in America are now devoting so much time and labour to the comparative study of religion. For many years the Trustees of the British Museum have had this object in view, and they have issued a most important series of facsimiles and works dealing with the "Book of the Dead"; the series was begun under the editorship of the late Dr. Birch, and has recently been continued under that of Dr. Wallis Budge, who has succeeded him in the keepership of the Egyptian and Assyrian antiquities at Bloomsbury. Of these publications, the "Egyptian Texts from the earliest period from the Coffin of Āmamu," which were published in facsimile with a translation by Dr. Birch, belong to the recension of the "Book of the Dead" which is found written upon coffins during the eleventh and twelfth dynasties; while the "Photographs of the Papyrus of Nebseni" placed in the hands of scholars one of the finest and most complete texts of the Theban recension of the work then known. In the year 1888 Dr. Wallis Budge, while in Egypt, acquired for the Trustees the famous Papyrus of Ani, which, dating from the second half of the eighteenth dynasty, is the most perfect and best illuminated of all papyri of the "Book of the Dead." Two years after its discovery it was published in facsimile, and in 1895 a second edition of the facsimile was issued, together with a translation and introduction from the pen of Dr. Budge. The texts thus published illustrate the history of the "Book of the Dead" in the period which lies between B.C. 2600 and B.C. 1700.

The volume just issued by the Trustees supplements these previous publications. It is larger than any of its predecessors, giving facsimiles, transcripts, translations, &c., of no less than five complete papyri of the "Book of the Dead," including a copy of the "Book of Breathings," a late form of composition to which the "Book of the Dead" was eventually reduced. These documents are all fine examples of the work, and they date from the beginning of the eighteenth dynasty to the end of the Ptolemaic period, that is, from about B.C. 1650 to B.C. 100. The series of publications on the "Book of the Dead," that has been issued by the Trustees at intervals during the last thirty-three years is therefore now complete.

In describing the contents of the volume it will not be possible within the limits of this review to do more than indicate roughly the general characteristics of the various papyri and the bearings each one has on the problems connected with the history and development of the great funereal work of the Egyptians. The first papyrus in the volume is that of Hunefer, an overseer of the palace and superintendent of the royal cattle, and "royal scribe" in the service of Seti I., King of Egypt about B.C. 1370. It is not a very long papyrus, but its vignettes are singularly beautiful. No other papyrus of the nineteenth dynasty is so finely illustrated, and as an artistic work it may be said to rank very little below the Papyrus of Ani. Perhaps the most interesting of the larger vignettes is the scene before the tomb on Plate 7. By the door of the tomb is set the sepulchral tablet of the deceased, and in front is seen the mummy of Hunefer, supported by the jackal-headed Anubis, one of the chief gods of the dead, who presided over the embalming of the mummy and accompanied the deceased into the presence of Osiris. Hunefer's wife and daughter kneel weeping at the mummy's feet, while behind are three priests performing ceremonies for the dead man's benefit and burning incense. Of the smaller vignettes the most interesting is the one at the very end of the papyrus, attached to Chapter xvii. (Plate 11); the vignette represents a cat, in front of the Persea tree, cutting off the head of a serpent, and symbolises the rising sun-god slaying the dragon of darkness—a legend that finds a place in the mythology of many other races.

The second papyrus in the volume is that of a lady named Ȧnhai, who was attached to the college of Ȧmen-Rā at Thebes, and who lived at the end of the twentieth or at the beginning of the twenty-first dynasty, *i.e.* about B.C. 1100. The vignettes are of an unusual character, and show that under the influence of the priests of Ȧmen the "Book of the Dead" was illustrated with scenes which do not belong to it by right, but are drawn from other works dealing with the Underworld. Of the vignettes an interesting one (Plate 6) shows the lady Ȧnhai binding up bundles of wheat and performing other duties in the Elysian fields. Another vignette represents the creation of the universe (Plate 8), and is an interesting variant to the similar scene depicted on the sarcophagus of Seti I. The third papyrus is that of Netchemet, who was in all probability the daughter of the priest king Ḥer-Ḥeru-sa-Ȧmen, who ruled over Egypt about B.C. 1000. This papyrus is inscribed in hieratic, and as it has not the beauty of colouring of the two first papyri in the volume, it has been reproduced in a series of half-tone blocks. The papyrus of Kerāsher, the fourth in the volume, is inscribed with a copy of the "Book of Breathings," a late form of the "Book of the Dead," dating from the late Ptolemaic or Roman period.

So far as the text of the "Book of the Dead" is concerned, by far the most valuable of the five papyri is the last in the volume, for it contains a number of chapters that have not hitherto been found in the Theban Recension, in addition to a good deal of rarely-found as well as quite new material. Nu was an officer in the house of the overseer of the Chancery, and the son of Ȧmen-hetep, and the papyrus dates from about B.C. 1650. It is the oldest illustrated copy of the "Book of the Dead" that is known.

We have only been able to give the briefest sketch of the contents of this very valuable book, but what we have said will suffice to indicate its importance, inasmuch as it presents a mass of new material for the study of the ancient Egyptian religion. Moreover, two out of the five papyri are written in the hieratic character, which of course is a sealed script to all but a few experts. Dr. Budge, however, has furnished them with transcripts into hieroglyphics, so that the book may be used as a chrestomathy by those who would acquire a knowledge of this interesting but difficult form of Egyptian writing. Of the value and interest of Dr. Budge's introductions and translations, appended to the various papyri, it is unnecessary to speak at length, for even before the publication of this work no other living scholar had done more than he for the study of the "Book of the Dead," both by the publication of new material and by the interpretation and translation of the entire work. The present volume is unique in its own sphere, and no private individual or firm of publishers could have undertaken the responsibility of such a production. The Trustees have earned the gratitude of scholars by making so much new material available for general study, and they are to be congratulated on the production of a monumental work which worthily carries on the scholarly traditions attaching to the Museum at Bloomsbury.

HAMILTON'S QUATERNIONS.

Elements of Quaternions. By the late Sir W. R. Hamilton. Second edition. Vol. I. Edited by C. J. Joly. Pp. xxxiii + 583. (London: Longmans, Green, and Co., 1899.)

FOR many years Hamilton's "Lectures" and "Elements" have been out of print, and the ardent student of quaternions was oftentimes unable to secure a copy of either of these great classics. Prof. Tait's treatise on quaternions is probably a better introduction for the beginner, who is more quickly brought into touch with the essential spirit of the method than he would be in Hamilton's pages. But he must, some time or other—unless he be a second Hamilton—bathe his mathematical being in the inexhaustible streams of quaternion analysis and symbolism that flow from the great master's mind. A second edition of Hamilton's immortal work is therefore to be warmly welcomed. English-speaking students will now be able to study Hamilton freely without having recourse to French or German translations; and it is our hope that the issue of this second edition will lead to a wider appreciation of the value of quaternions as a mathematical method peculiarly adapted to the geometry of space and general problems in dynamics.

The new edition is printed by direction of the Board of Trinity College, Dublin, and is edited by Prof. Joly. In the larger size of page and larger and wider type there is a great improvement on the original form, although it has necessitated dividing the book into two volumes. The small print has been done away with altogether. This, in itself, no doubt is better for the reader; but the advantage is lost that he can no longer discern at a glance what is illustration and particular from what is general and fundamental. For example, in the very important sections on the linear and vector function, one of the most beautiful of Hamilton's creations, the reader cannot pick out so readily as in the original edition the broad line along which the fundamental properties of this function are developed. Many of the illustrations are really of the character of examples, such as Prof. Tait puts at the end of his different chapters. Printing these in the same style as the more important parts tends to give them a fictitious value, and to blurr the whole perspective of the book.

The editor has added occasional notes to elucidate points which might appear obscure to the student. In some of these a different line of proof may be suggested, or they may simply amount to a reference to another section. Prof. Joly has exercised this editorial function with judgment. One of the longest of these notes is appended to the chapter on the well-known i, j, k relations, and brings out clearly the necessity for the negative sign of the square of a vector, *if the associative law in products is to hold.* The system which is built on the assumption that $i^2=j^2=k^2=+1$ is ascribed to Mr. Oliver Heaviside. It ought, strictly speaking, to be ascribed to O'Brien, a contemporary of Hamilton's.

We are not called upon at this date to consider the merits of Hamilton's great calculus. The objections taken to it by mathematicians great and small have been so curious and, in some cases, so puerile that we doubt if these critics have ever seriously set themselves to study its true character. One really eminent mathematician who had been fortunate enough to pick up a copy of Hamilton's "Lectures" for a trifling sum, gladly transferred his prize next day to a friend, remarking that the man must have been mad who invented quaternions, for he made two sides of a triangle equal to the third side! Maxwell adopted the compact suggestive notation in his "Electricity and Magnetism"; and many of the transformations which are so necessary now-a-days in connection with electromagnetic waves, and take a page or two to effect in ordinary notation, are done almost by inspection by quaternion methods. Maxwell did not use the quaternion method, not because he regarded it as inferior to the notation, as one writer has with curious logic argued, but simply because the world was not ready for it. Let us hope that with this handsome re-issue of one of the most characteristic works of our century a renewed interest will be taken in the study of quaternions, so that in the near future operations and notations alike may be freely used in works on mathematical physics. Prof. Joly deserves the gratitude of all for his labour of love. When we remember the peculiar characteristics of Hamilton's style, with its redundant italics and capitals, we realise the hardness of the task the editor has set himself in reproducing to the letter (barring misprints) this great monumental work.

One word in conclusion. Is no new edition of the "Lectures" to be brought out—or at any rate of Lecture vii., which is nearly as long as the other six put together? A re-issue of Lecture vii., with perhaps an introductory chapter giving the fundamental principles of the calculus, would confer a boon on many students. In this so-called "Lecture," the great mathematician moves with a giant stride over the greater part of the whole field of geometry and dynamics. From it alone Tait drew his inspiration.

C. G. K.

OUR BOOK SHELF.

A Short History of the Progress of Scientific Chemistry in our own Times. By Prof. W. A. Tilden. Pp. x + 276. (London: Longmans, Green, and Co., 1899.)

IN size and scope Prof. Tilden's short history recalls Wurtz' brilliant little "History of Chemical Theory," published thirty years ago. But whereas the key-note of Wurtz' book was the "immortal memory" of Lavoisier, and its main theme the vindication of French chemists *contra mundum*, the spirit of Dr. Tilden's book lies in its impartiality and sound judgment. In mode of treatment, too, the authors differ. Wurtz, with more personal touches and controversial points, traces the main ideas of chemical combination from the time of Lavoisier continuously to his own; Prof. Tilden, adopting the more natural lecture method, has given us separate histories of the main lines of chemical progress during the Victorian era. We cannot doubt but that the student will find the modern book handier to consult, and sounder, though possibly less stimulating, than its predecessor.

The difficult task of selection has been, on the whole, successfully met by Prof. Tilden. We can heartily commend for its lucid treatment the chapter on stereochemistry, and "the classification of the elements" for its historical completeness and common sense.

The few slips we have observed are mainly printer's errors, *e.g.* the date of the "Sceptical Chymist" is given as 1680 (p. 38). In the account of Dumas' experiments on the composition of water, we are told that the retention of hydrogen by the reduced copper was unsuspected in Dumas' time (p. 80); but Dumas himself refers to this error in his original paper. Prof. Tilden repeats the usual derivation of gas, "Gas = geist = spirit." But since the publication of "Gas" in Dr. Murray's Dictionary we thought the derivation from chaos had been accepted. Perhaps we may quote the full passage from Van Helmont, which occurs in the "Progymnasma Meteori" (p. 69, ed. 1682): "Verum quia aqua in vaporem, per frigus delata, alterius sortis, quam vapor per calorem suscitatus; ideo paradoxi licentia, in nominis egestate, halitum illum gas vocavi non longe a Chao veterum secretum."

La Géologie Expérimentale. Par Stanilas Meunier, Professeur de Géologie au Muséum d'histoire naturelle de Paris. Avec 56 figures dans le texte. Pp. 306. (Paris: Félix Alcan, 1899.)

IN this work, which has just been added to the "Bibliothèque Scientifique Internationale," Prof. Meunier has aimed at supplying a complete and practical series of experimental illustrations of as many different geological phenomena as possible — in this respect going even farther than did the late M. Daubrée in his classical "Études Synthétiques de Géologie Expérimentale." The work is founded on a course of lectures given in Natural History Museum of Paris in 1898; and in the Geological Gallery of the Museum in the Jardin des Plantes may be seen the actual apparatus, designed by the author and others, for carrying on the experiments described in these pages.

After a general introduction on the value and limits of the experimental method as applied to geological teaching and research, in which the author replies very effectively to the objections which have been raised to it, he proceeds to treat systematically with the questions involved in supplying experimental illustrations of geological phenomena. He first deals with the results produced by the action of external forces operating on the earth's crust. These are classed as the phenomena of denudation and of sedimentation. Under the first head are classed the action of rain, of rivers, of the sea and lakes, of ice, of subterranean waters and of the wind. It is noticeable that the experiments, many of which are of a novel character, are for the most part such as can be performed with very simple apparatus, of a kind which any ingenious lecturer may readily provide himself with at a relatively small cost, and the experiments are certainly calculated to give point and value to the teaching they are intended to illustrate. The various kinds of sedimentation are treated of in the same way, the action of rain, rivers, seas and lakes, subterranean waters and wind in accumulating materials to form new rocks being successively handled. In the second part of the work we have a series of experiments to illustrate the action of the internal forces at work on the earth's crust. The origin of crystalline rocks, including illustrations of vitrification and devitrification, metamorphism, both contact and regional, and the origin of mineral veins are discussed in a somewhat summary manner, with reference chiefly to work that has been carried on in France; and this division of the book ends with a rather speculative chapter on the more deeply-seated materials of the globe. The third part of the work deals with volcanoes, earthquakes and the production of mountain-chains. Although the treatment of the various questions is—perhaps necessarily—somewhat unequal, no teacher of geology can fail to gather from this work of Prof. Meunier many useful hints which will prove of great value in illustrating the action of the various forces which have contributed to the production of the features of the earth's crust, while the student and general reader will find it equally full of suggestiveness and novelty.

The Fauna of Shropshire: being an Account of all the Mammals, Birds, Reptiles and Fishes found in the County of Salop. By H. E. Forrest. Pp. viii + 248 + vi; illustrated. (Shrewsbury and London, 1899).

THIS little book, excellent in its way as a local vertebrate fauna, is somewhat more than its title implies. It gives, for instance, a very well-written and interesting account of the habits of many species of British mammals, more especially the smaller and commoner kinds. Particular attention may be directed to the life-histories of the mole and the shrew, some of the facts in the former being new to us. The great feature of the book is the very excellent account of the mode of development and general habits of the British Amphibia; this group of animals being apparently the author's favourite subject of study. The reptiles are treated nearly as fully as the frogs and newts; and here we may notice that the author considers that the legend of the viper's swallowing its young may prove to be based on fact. A much smaller proportionate amount of space is devoted to the birds, for the reason that the author hopes to elaborate this portion of his subject on a future occasion.

Although the illustrations, which are chiefly taken from mounted groups, are less satisfactory than they might be, the work may be commended not only to the naturalists of Salop, but to those of the British Islands generally.

R. L.

La Pratique du Maltage. Par Lucien Lévy. Pp. 248. (Paris: G. Carré et C. Naud, 1899.)

THIS work, which may be classed as belonging to the best type of modern technical literature, is based on a series of lectures given by Prof. Levy at the "Institut des Fermentations de l'Université Nouvelle" of Brussels. At present there is a very open field for such a book, for during recent years no other work devoted specially to malting has been published which attempts, like the one before us, to combine the scientific and practical sides of the question. The work will have most value to readers in this country for the very complete account it contains of recent scientific work connected with germination; this is given in a very clear and concise form, and the most recent researches of any importance are referred to. The more technical portions of the book bear a continental stamp, and in certain places lead us to think that there are some things connected with malting we do better in England. However this may be, the work as a whole is recommended to those interested in malting as the best technical treatise on the subject at present published; but it should be borne in mind that it is specially written for students on the continent, where the method of malting differs somewhat from ours. The printing, paper, and binding of the book are particularly good.

A. J. B.

Curiosities of Light and Sight. By Shelford Bidwell, M.A., LL.B., F.R.S. Pp. xii + 226. (London: Swan Sonnenschein and Co., Ltd., 1899.)

MANY readers will be glad to possess this collection of essays, in which Mr. Shelford Bidwell describes some of the experiments which the scientific world owes to his ingenuity. The five chapters in the volume are based upon notes of lectures delivered to various audiences; and their subjects are: light and the eye, colour and its perception, some optical defects of the eye, some optical delusions, and curiosities of vision. Each subject is presented with freshness of style, and elucidated by many simple and convincing experiments. To the popular lecturer on science, who desires to know how to produce curious and instructive optical effects, the volume will be very acceptable, and every physical experimentalist may confidently turn to it for inspiration. But though the curiosities of colour phenomena, and of sight generally, are chiefly described in the book, many questions of deep interest to students of both physical and physiological optics are discussed, so that the volume appeals to scientific as well as popular readers.

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.*]

A Curious Salamander.

THE artificial propagation of food fishes is an important part of the work of the United States Fish Commission, and for this purpose it has a number of hatcheries or "stations" scattered throughout the Union. At each of these stations especial attention is given to the rearing of the fishes best adapted to the region in which that particular station is placed, as it would be useless to breed salmon or trout for the warm, sluggish streams of the South, or to put bass and carp into the cold, swift rivers of New England or of Michigan. The sea stations are devoted to the study of marine zoology, and the propagation of shad, mackerel, cod, lobsters and similar organisms that cannot be bred in fresh water; while hatcheries have been put on the banks of several lakes at which whitefish, land-locked salmon, lake trout and the like are reared.

A few years ago a station was established near the town of San Marcos, Texas, for the culture of black bass and "crappies." A prime essential for fish hatching is a copious supply of water, and the supply should be as uniform in amount, temperature and composition as it is possible to obtain. If there be much sediment in the water, it will be deposited on the eggs and suffocate them; and sudden variations in temperature may also be fatal. As the rainfall in western Texas is untrustworthy, the Commission determined to bore an artesian well to supply the water for its new station.

The well was bored successfully and a flow of twelve-hundred gallons per minute obtained from a depth of 188 feet. There are several such wells in this region that give this amount or more, but soon after the San Marcos well was opened a number of living animals began coming up with the water. So far, four kinds of Crustacea and a salamander have been seen, and of these quite a number have been obtained. The Crustacea are new to science and were described by Dr. James E. Benedict, of the Smithsonian Institution. They are white and perfectly blind. Most of the shrimps and crab-like animals have eyes set on the extremities of stalks that project above the surface. The shrimps from this well have the stalks, but the eyes have disappeared.

The most remarkable creature that has come from the well is the blind salamander, the *Typhlomolge Rathbuni.* The name

FIG. 1.—*Typhlomolge Rathbuni*, seen from above. (Photographed by W. P. Hay.)

is compounded from the Greek *typhlos*, blind, and *molge*, a kind of salamander; while the second term was given in honour of Mr. Richard Rathbun, the Assistant Secretary of the Smithsonian Institution, and for many years the Chief of the Division of Scientific Inquiry of the Fish Commission. This animal is a new species and a new genus. It was described by Dr. L. Stejneger, of the Smithsonian Institution. The *Typhlomolge* is from three to four and a half inches in length. It has a large head, protruding forward into a flattened snout that bears the mouth. The eyes are completely covered by the skin, and are visible from the outside only as two black specks. Just behind the head are the gills. These are external and stand out in festoons about the neck, instead of being covered by a lid as in fishes. The skin is a dingy white, and the sharp contrast between

FIG. 2.—*Typhlomolge Rathbuni*, ¾ life. (Photographed by W. P. Hay.)

the colourless skin and the vivid scarlet of the exposed gills makes the appearance of this subterranean visitor striking in the extreme. It has four long, slender legs, that are gruesomely human in appearance, and are supplied with feet that are startlingly hand-like. The fore feet bear four fingers or toes and the rear ones have five, and though the legs are extremely slender, they possess a considerable amount of strength. Behind, the body terminates in a flattened tail that bears a fin like that of an eel.

In April 1899, two living specimens of this strange being were shipped by mail from San Marcos to the head office of the Fish Commission in Washington. They bore the journey of nearly 1800 miles, and reached their destination in good condition. They excited great interest, and for some time after their arrival a wondering group of spectators crowded about the aquarium into which they were put. These living specimens corrected several errors that had been made from observations of the dead bodies only. The legs are used for locomotion, and the animals creep along the bottom with a peculiar movement, swinging the legs in irregular circles at each step. They climb easily over the rocks piled in the aquarium, and hide in the crevices between them. All efforts to induce them to eat have been futile, as has also been the case with blind cave fish in captivity and they are either capable of long fasts or live on infusoria in the water.

From whence do these strange creatures come? The well is sunk in limestone, and that renders it likely that there may be some great cavern or subterranean lake communicating with it, but the rock through which the hole is bored is solid, except for a single channel two feet in diameter. The fact that the water rises nearly two hundred feet shows it to be under great pressure, and altogether this well affords material for study to geologists as well as zoologists.

Washington, D.C. CHARLES MINOR BLACKFORD.

Palæolithic Implement of Hertfordshire Conglomerate.

THE rudely-made Palæolithic implement, illustrated to half the actual size in the accompanying engraving, is probably unique in the highly intractable material from which it is made. It was found by me in May last with Palæolithic implements of flint in the Valley of the Ver, Markyate Street, near Dunstable: its weight is 1 lb. 6¼ oz.—1677 in my collection. Although rude, there is no doubt whatever as to its true nature; there is a large bulb of percussion on the plain side, as seen in the edge

FIG. 1.—Palæolithic implement of Hertfordshire Conglomerate. One-half actual size.

view, and the hump-backed front is chipped to a rough cutting edge all round, each facet going right through the embedded pebbles. Its condition is totally different from a newly-broken block of Conglomerate, and indeed of Conglomerate broken in Roman times by quern-makers. It is faintly ochreous from being long embedded in clay, and sub-lustrous. Newly-broken Conglomerate is in colour a lustreless cold grey. The peculiar nature of the material would not admit of finer work: I have tried hard to flake Conglomerate without the slightest success; it breaks only after the heaviest blows, and then in the most erratic manner, the embedded pebbles often flying from the matrix. Sir John Evans has seen this example, and agrees with my conclusions as above expressed; he also informs me that several years ago he found what appears to be the point of a lanceolate implement of the same material and of Palæolithic character on the surface of a field near Leverstock Green.

Dunstable. WORTHINGTON G. SMITH.

On the Calculation of Differential Coefficients from Tables Involving Differences; with an Interpolation-Formula.

(1) IN NATURE for July 20 (p. 271) Prof. Everett has given formulæ for calculating first and second differential coefficients in terms of differences. The formulæ can be more simply expressed in terms of "central differences." Let the values of a function u_x be given for $x = \ldots, -2, -1, 0, 1, 2, \ldots$; then, with the usual notation,

$$\Delta u_0 = u_1 - u_0$$
$$\Delta^2 u_0 = \Delta u_1 - \Delta u_0 = u_2 - 2u_1 + u_0,$$
&c.

Now write

$$\tfrac{1}{2}(\Delta u_0 + \Delta u_{-1}) = a_0$$
$$\Delta^2 u_{-1} = b_0$$
$$\tfrac{1}{2}(\Delta^3 u_{-1} + \Delta^3 u_{-2}) = c_0$$
$$\Delta^4 u_{-2} = d_0$$
&c.

Then $a_0, b_0, c_0, d_0, \ldots$ are the "central differences" of u_0. Take, for instance, the following table:—

y	e^y	Δ			
4·7	109·947				
		11563			
4·8	121·510		1217		
		12780		126	
4·9	134·290		1343		17
		14123		143	
5·0	148·413		1486		12
		15609		155	
5·1	164·022		1641		19
		17250		174	
5·2	181·272		1815		15
		19065		189	
5·3	200·337		2004		24
		21069		213	
5·4	221·406		2217		18
		23286		231	
5·5	244·692		2448		28
		25734		259	
5·6	270·426		2707		
		28441			
5·7	298·867				

Writing $y = 5{\cdot}2 + {\cdot}1x$, and $u_x = 10^3 e^y$, so as to get rid of decimals, we have the following values corresponding to $y = 5{\cdot}2$ $(x = 0)$:—

u_0	a_0	b_0	c_0	d_0	e_0
181272	18157½	1815	181½	15	2½

With this notation, the value of u_x for values of x between $-\frac{1}{2}$ and $+\frac{1}{2}$ is given by

$$u_x = u_0 + xa_0 + \frac{x^2}{2!}b_0 + \frac{x(x^2-1)}{3!}c_0 + \frac{x^2(x^2-1)}{4!}d_0 + \frac{x(x^2-1)(x^2-4)}{5!}e_0 + \ldots \ldots \text{(i.)}$$

This is a well-known formula. Differentiating with regard to x, and putting $x = 0$, we have (writing u for u_x)

$$\left(\frac{du}{dx}\right)_0 = a_0 - \tfrac{1}{6}c_0 + \tfrac{1}{30}e_0 - \tfrac{1}{140}g_0 + \ldots \ldots \text{(ii.)}$$

Similarly, differentiating twice, and putting $x = 0$,

$$\left(\frac{d^2u}{dx^2}\right)_0 = b_0 - \tfrac{1}{12}d_0 + \tfrac{1}{90}f_0 - \tfrac{1}{560}h_0 + \ldots \ldots \text{(iii.)}$$

Prof. Everett's formula for the "increase-rate" when fifth differences are negligible is obtained by taking the first two terms of (ii.).

(2) The advantage of these formulæ, as Prof. Everett points out, is their greater accuracy. The ordinary formula

$$\Delta - \tfrac{1}{2}\Delta^2 + \tfrac{1}{3}\Delta^3 - \tfrac{1}{4}\Delta^4 + \tfrac{1}{5}\Delta^5,$$

in the above example, would give for $y = 5{\cdot}2$

$$\frac{du}{dx} = 18131\tfrac{1}{2},$$

while, if the differences were taken backwards, we should get

$$\frac{du}{dx} = 18124\tfrac{1}{5}.$$

The formula (ii.), taken to the fifth central difference, gives

$$\frac{du}{dx} = 18127\tfrac{1}{3},$$

the true value being

$$\frac{du}{dx} = 18127{\cdot}224.$$

The inaccuracy in the ordinary formula is, of course, due to the fact that a table such as the above never gives the exact value of the function tabulated, but only the nearest integral multiple of a certain unit (in this case ·001). If we denote this unit by ρ, each tabulated value differs from the true value by some quantity lying between $-\frac{1}{2}\rho$ and $+\frac{1}{2}\rho$. It may be shown that this makes it possible for $\Delta - \frac{1}{2}\Delta^2 + \frac{1}{3}\Delta^3 - \frac{1}{4}\Delta^4$ to differ from its true value by as much as $\frac{16}{3}\rho$, while $a_0 - \frac{1}{6}c_0$ cannot differ from its true value by more than $\frac{3}{4}\rho$. Hence this latter formula is more accurate than the ordinary one in the ratio of 64 : 9, or about 7 : 1, when fifth differences are negligible. When only seventh differences are negligible, the formula $a_0 - \frac{1}{6}c_0 + \frac{1}{30}e_0$ is more accurate than the ordinary formula, in the ratio of 832 : 55, or about 15 : 1.

(3) The formulæ (ii.) and (iii.) give the first and second differential coefficients for the values of the "argument" shown in the table. It is often more useful to have them for the *intermediate* values. This requires a modification of the method of central differences. Let us write

$$\begin{aligned} \tfrac{1}{2}(u_1 + u_0) &= V \\ \Delta u_0 &= \Delta_1 \\ \tfrac{1}{2}(\Delta^2 u_0 + \Delta^2 u_{-1}) &= \Delta_2 \\ \Delta^3 u_{-1} &= \Delta_3 \\ &\text{\&c.} \end{aligned}$$

Thus for the interval from 5·2 to 5·3, in the above example, we have

V	Δ_1	Δ_2	Δ_3	Δ_4	Δ_5
190804½	19065	1909½	189	19½	9

With this notation, it may be shown that, for any value of x from 0 to 1,

$$\begin{aligned} u_x = &\left\{V - \frac{1-2x}{2}\Delta_1\right\} \\ &- \frac{x(1-x)}{2\,!}\left\{\Delta_2 - \frac{1-2x}{6}\Delta_3\right\} \\ &+ \frac{x(1-x^2)(2-x)}{4\,!}\left\{\Delta_4 - \frac{1-2x}{10}\Delta_5\right\} \\ &- \frac{x(1-x^2)(4-x^2)(3-x)}{5\,!}\left\{\Delta_6 - \frac{1-2x}{14}\Delta_7\right\} \\ &+ \ldots\ldots\ldots\ldots \quad \text{(iv.)} \end{aligned}$$

Or, if we write $x = \frac{1}{2} + \theta$, then for values of θ from $-\frac{1}{2}$ to $+\frac{1}{2}$,

$$\begin{aligned} u_{\frac{1}{2}+\theta} = &\{V + \theta\Delta_1\} \\ &- \frac{1-4\theta^2}{2^2.2\,!}\left\{\Delta_2 + \tfrac{1}{3}\theta\Delta_3\right\} \\ &+ \frac{(1-4\theta^2)(9-4\theta^2)}{2^4\,.\,4\,!}\left\{\Delta_4 + \tfrac{1}{5}\theta\Delta_5\right\} \\ &- \ldots\ldots\ldots\ldots \quad \text{(v.)} \end{aligned}$$

Differentiating this last expression twice with regard to θ, and putting $\theta = 0$ we find

$$\left(\frac{du}{dx}\right)_{\frac{1}{2}} = \Delta_1 - \frac{1}{24}\Delta_3 + \frac{3}{640}\Delta_5 - \frac{5}{7168}\Delta_7 + \ldots\ldots \quad \text{(vi.)}$$

$$\left(\frac{d^2u}{dx^2}\right)_{\frac{1}{2}} = \Delta_2 - \frac{5}{24}\Delta_4 + \frac{259}{5760}\Delta_6 - \frac{3229}{322560}\Delta_8 + \ldots\ldots \quad \text{(vii.)}$$

Thus for $y = 5{\cdot}25$, in the above example, we find

$$\frac{du}{dx} = 19057{\cdot}17,$$

the true value being

$$\frac{du}{dx} = 19056{\cdot}63.$$

(4) The formula (iv.) is useful for constructing tables by means of interpolation. For halving the intervals in a table, it gives

$$u_{\frac{1}{2}} = V - \tfrac{1}{8}\Delta_2 + \frac{3}{128}\Delta_4 - \frac{5}{1024}\Delta_6 + \frac{35}{32768}\Delta_8 - \ldots \quad \text{(viii.)}$$

Similarly, for subdivision of the intervals into fifths,

$$\left.\begin{aligned} u_{\frac{1}{5}} = V &- {\cdot}3\Delta_1 - {\cdot}08\Delta_2 + {\cdot}008\Delta_3 + {\cdot}0144\Delta_4 - {\cdot}000864\Delta_5 \\ &- {\cdot}0029568\Delta_6 + {\cdot}00012672\Delta_7 + {\cdot}000642048\Delta_8 - \ldots \\ u_{\frac{2}{5}} = V &- {\cdot}1\Delta_1 - {\cdot}12\Delta_2 + {\cdot}004\Delta_3 + {\cdot}0224\Delta_4 - {\cdot}000448\Delta_5 \\ &- {\cdot}0046592\Delta_6 + {\cdot}00006656\Delta_7 + {\cdot}001018368\Delta_8 - \ldots \\ u_{\frac{3}{5}} = V &+ {\cdot}1\Delta_1 - {\cdot}12\Delta_2 - {\cdot}004\Delta_3 + \text{\&c.} \\ u_{\frac{4}{5}} = V &+ {\cdot}3\Delta_1 - {\cdot}08\Delta_2 - {\cdot}008\Delta_3 + \text{\&c.}\,; \end{aligned}\right\} \text{(ix.)}$$

the terms in $u_{\frac{3}{5}}$ and $u_{\frac{4}{5}}$ being the same as in $u_{\frac{2}{5}}$ and $u_{\frac{1}{5}}$, but with signs alternately alike and different; and the sequence of signs in each case being . . . + + − − + + . . . The corresponding formulæ for subdivision into tenths might be found: but it is simpler to subdivide into halves and then again into fifths.

When several differences have to be taken into account, the above method of direct calculation is less troublesome than the ordinary process of building up the table by calculation of the sub-differences.

In the formulæ (ix.) the terms due to V and Δ_1 have been given in the form $V - {\cdot}3\Delta_1$, $V - {\cdot}1\Delta_1$, . . . ; but in practice these terms would be obtained by successive additions of ·2Δ to u_0, so that it is not necessary to calculate V.

August 16. W. F. SHEPPARD.

Apparent Dark Lightning Flashes.

ON the evening of the 5th of the present month we were visited by a severe thunderstorm, which passed practically over this place. The lightning was very vivid and at times occurred at intervals of only a few seconds. In order to photograph some of the flashes I placed a camera on my window sill and exposed four films for consecutive periods of 15 minutes each.

During the exposures I was observing the sky, and repeatedly found that after nearly each bright flash I could see distinctly a *reversed image* of each flash *in any part of the sky* to which I turned my head. These apparent dark flashes, or rather the images on my retina, lasted for sometimes 5 to 10 seconds. At the time I wondered whether dark flashes had ever been noticed before, and thought that this phenomenon was not uncommonly observed, but seeing Lord Kelvin's letter in your issue of August 10, I send this note in case it may prove of interest.

Westgate-on-Sea, August 13. WILLIAM J. S. LOCKYER.

Subjective Impressions due to Retinal Fatigue.

IN reading the interesting optical experience as described by Lord Kelvin in NATURE of August 10, it occurred to me that a somewhat similar effect on the eye, as noticed by myself, might be of interest.

Frequently late in the evening, and with a dull cloudy sky, I have seen my own figure, at least in part, apparently projected in gigantic form high up on the cloudy background.

This happened in the following manner. Going to the door of the house, and standing there with the strong light from the lobby or hall lamp shining out upon the gravel-walk in front, I saw my figure in shadow strongly defined upon the illuminated pathway. On raising my eyes quickly to the sky, I there saw the same form marked out on the dark clouds, but in a lighter shade.

The effect on the eye, as in Lord Kelvin's experience, is doubtless that of fatigue: in my experience, however, the form observed being very dark as compared with the illuminated background, I received the complementary impression of a light-coloured figure on a dark background.

The time during which this impression remained when looking at the clouds might be a couple of seconds.

August 14. W. J. MILLAR.

Mathematics of the Spinning-Top.

IT should have been stated on p. 321 that, while θ_3 is the angle between HQ and HQ′ in Fig. 1, p. 347, the angle between HS and HS′ is θ_2. At the same time this opportunity is available for some corrections, for which the printers are not responsible. On p. 321 the values of sin θ_3 and sh θ_1 should be interchanged; on p. 348, after equation (35), read ... "MX is the harmonic mean of MT, MT′ and of Mm, Mm', ..."

August 12. A. G. GREENHILL.

ON SPECTRUM SERIES.[1]

II.

IT is well that I should indicate the basis of these statements, and for this purpose I throw on the screen a very small part of the spectra of two or three different substances in order that you may see the way in which the work has been done. Take the lowest horizon. There we are dealing with zinc, and you see the way in which the triplets have been picked out. The triplet in each case, of course, supposing it is the remnant of a fluting, has its central line nearer to one side of the triplet than the other. All the triplets in the zinc spectrum are perfectly symmetrical from that point of view. If we take the upper spectrum—that of calcium—we find also that the triplets are formed in exactly the same way. We can quite understand the enormous labour which has been involved on the part of the inquirers I have named in working out from the spectra of a great many substances and from all the different regions of the spectrum, visible and photographic, these delicate triplets. In a great many cases they do not represent the strongest lines, those most easily seen, and they want a great deal of looking for.

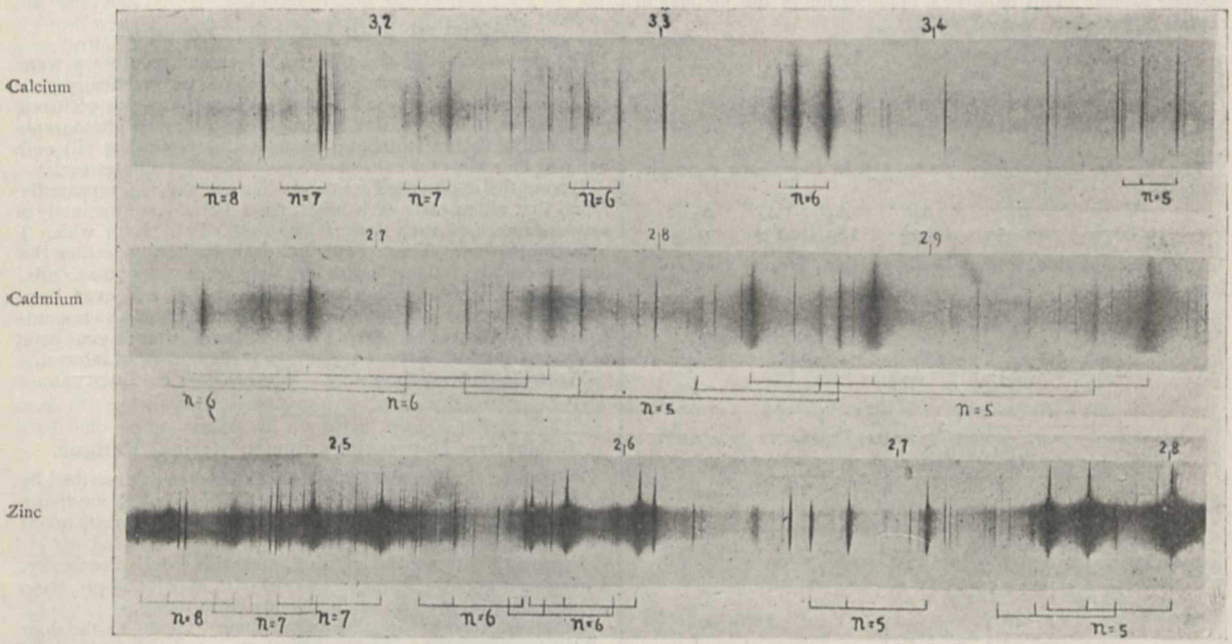

FIG. 6.—Parts of the spectra of calcium, cadmium and zinc showing the triplets.

I next pass on to some more general statements, which I am anxious to put before you for the reason that you will not find them stated in any literature that I am acquainted with; the subject has really not been generally discussed at all.

Some substances have three series, as in the case of helium and asterium. There are others like them; and the most remarkable case which I have to bring before you is that of hydrogen. We do not know the meaning of it yet, but it has to be taken into account in any consideration of these questions. Until a little time ago only one series was known in the spectrum of this gas, and it was thought that on that account the atom of hydrogen was far more simple than that of any other chemical elements. A short time ago, however, Prof. Pickering, in his magnificent work on the stars, to which I have already had the opportunity of referring, discovered a second series of lines. Not long after, Prof. Rydberg suggested that one of the most important lines seen in a large group of stars really represented a line of the principal series of hydrogen. That conclusion has been generally accepted, although the evidence is considered doubtful by some; so that we now assume that hydrogen has three series like helium and asterium, and we seem therefore to be on solid ground in one direction, at all events, in regard to some gases. We have another series of metals of low atomic weight, and which therefore chemically are supposed to represent a considerable simplicity; we find that in the case of lithium and sodium we also deal with three series, a principal series and two subordinate series. The series of lithium are just as beautiful in their rhythm as the other series to which I have referred. The same remark applies exactly to sodium. Now, it has recently been found that sulphur and selenium also give us three series. We have a principal series and the first and second subordinates, but the suggestion of anything beyond these three is confined to one or two lines in each case. Next let us take another gas, and see what happens in the case of oxygen. *We have six series*, that is twice as many as we know of in hydrogen, helium, asterium, lithium, sodium, sulphur, and so on. I should say that so far as that goes we are in the same condition that we were some time ago when we imagined that the gas obtained from the mineral cleveite was really a single gas with six series. Very many arguments have been employed to show that that view is probably not an accurate one; so that some are prepared to separate the cleveite gases at spark temperatures into two, calling one helium and the other asterium. That brings these two constituents of the cleveite gas then to the same platform as hydrogen with the recent developments, lithium, sodium, sulphur, &c. If we come to consider this extraordinary condition in the case of

[1] A Lecture to Working Men, delivered at the Museum of Practical Geology, on May 1, by Prof. Sir Norman Lockyer, K.C.B., F.R.S. (Continued from p. 370.)

oxygen a little further, we find that the six series only after all pick up the oxygen lines seen at a low temperature, and that if we employ a high temperature to observe the oxygen spectrum, that is to say, if we use an induction coil, a jar and an air break, we find a very considerable number of lines indeed which have no connection whatever with the series. And we are face to face with this very awkward fact, that in the case of oxygen there are more lines which we cannot get into a series than there are lines in the six series which we have attributed to that chemical substance. Here, therefore, we begin certainly to get into difficulties. The inquiry is not so straightforward, the conditions are not so constant, as we might have expected them to be.

Here then we have instead of three series twice that number, and these only account for about half the lines. Now, let us look still a little further. The next point is that in the case of other substances *we have no principal series*, but only two subordinate ones. This happens in the case of magnesium, calcium and strontium. We have only two series in the case of magnesium, two in calcium, and two in strontium. In all those three we have a first and second subordinate series, but no principal series. I have studied the lines of calcium and magnesium, in the same way that the lines of oxygen were studied to see how many of the lines are picked up by the series. In the upper part of the diagram we have the lines seen in the arc spectrum of calcium, and in the two next horizons we have the lines picked up in the first and second subordinate series. The next horizon gives the residual lines—lines, that is, which have not been distributed into any of these series. You see that there is a large number outstanding just as in the case of oxygen, and it is very important indeed to note that the two lines H and K, which are more conspicuous in the spectrum of the sun than all the other lines of the spectrum, have not been caught by any of these researchers into the series of calcium. Therefore, with a reduced number of series, we seem to be getting still further from the simplicity we began with in the case of some of the permanent gases like hydrogen and helium. The same thing holds with regard to magnesium, the spectrum of which at the temperature of the arc has not so many lines in it as the spectrum of calcium. A certain number of these lines has been picked up to form the series, but we get numerous lines which have been left over after all attempts to sort them into series have been made.

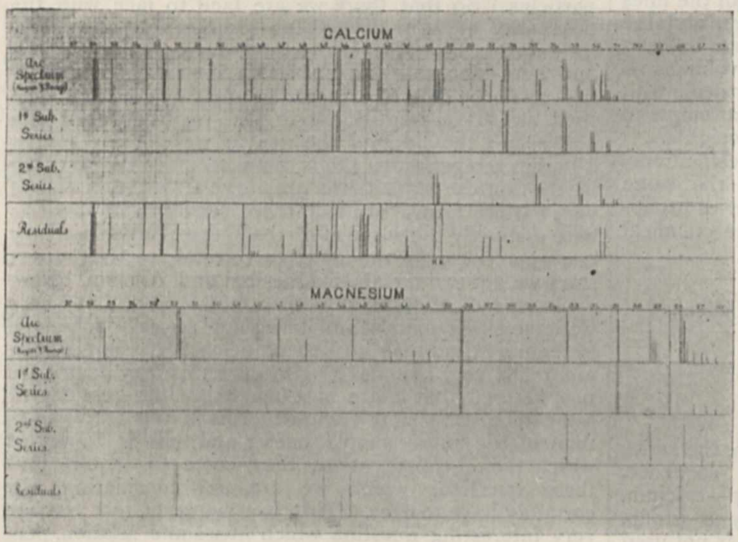

FIG. 7.—Map showing series and residual lines in spectra of calcium and magnesium.

I have now to bring before you another consideration. We are dealing in the case of calcium and magnesium with arc temperatures, but I showed you in my first lecture that in the case of calcium and magnesium the all-important lines in the hottest stars were lines seen at the temperature of the spark. I have added these lines to the diagram, and you will see that there is not the slightest trace of those lines having been picked up in the series. So that the further we go, the more we seem to get away from that beautiful simplicity with which we began. I take you now to another group of substances, namely, tin, lead, arsenic, antimony, bismuth and gold, and I might mention more. No series whatever have as yet rewarded the many attempts of those who have tried to get those metals and non-metals on all-fours with those previously investigated. It remained for Kayser and Runge to point out that it looked very much as if this complete absence of series was connected with the melting point of the substances with which they had been dealing. So long as the melting point was low, as in the case of sodium and lithium, the normal three series would show at low temperatures; and, further, there were no lines over. But, when you get to these substances with high melting points, there is no series at all, and of course it is suggested that therefore there must be intermediate stages; and that really seems to be a very valid suggestion indeed, and one which in all probability will enable us to get over some of the difficulties. They point out that in the case of lithium, sodium, potassium, &c., all the lines are picked up, and that in the case of copper, silver and gold the series pick up only a very small proportion. There seems, therefore, to be a progression of complexity with the increasing melting point with regard to all the metallic substances which have so far been examined; of course this consideration does not touch the question of oxygen. Oxygen is a gas, hydrogen is a gas in consequence, of course, of their very low melting points, and you know that quite recently it has been found possible to liquefy both of them. So that there must be something different in their case, and it seems extremely encouraging to find, therefore, that the same variation, the same breaking away from the law which I pointed out in the case of some of the metals, should really occur also in a gas, because it seems as if we shall be able to explain the phenomena in both cases by supposing that there is a condition of greater complexity, and that when we follow up this line of greater and greater complexity, whether in a gas such as oxygen, or in a solid such as gold, we do not get the simple series, because at the temperatures we employ we are still far from the simple condition which we can get at in some gases and in some metals with low melting points. The table gives the relation between the melting point and the percentage of lines sorted into series. Thus, in the case of barium with a high melting point we get no lines at all represented in the series; then we gradually get up to 100 per cent. in the case of lithium. But then again, as in the case of oxygen, when we come to mercury, which is also of low melting point, instead of getting 100 per cent. we only get about 25 per cent. of the lines represented in the series.

Relation of series to melting points.

Element	Melting point	Percentage of series lines
Barium	1600°	0
Gold	1200	4
Copper	1050	6
Silver	960	26
Strontium ...	700	20
Calcium	700	34
Magnesium ...	600	64
Zinc	410	80
Cadmium ...	320	50
Lithium	180	100
Sodium	90	100
Cæsium... ...	62	100
Potassium ...	58	100
Rubidium ...	38	100
Mercury... ...	− 40	27

These matters, of course, have been very carefully inquired into, and among them I will just point out that Meyer has shown that if the wave-lengths of all the lines for $n=\infty$ be calculated and put as ordinates, and the atomic weights as abscissæ, then all the points lie on a curve similar to that which gives the atomic volumes as functions of the atomic weights. He not only deals with the melting points, but he goes further and attempts to associate the melting points with the atomic weights.

The next consideration is that in these investigations, in some cases, the series have reproduced the same chemical group, but in some instances the series groupings, so to speak, are quite different from the chemical groupings.

The facts so far ascertained are as follows :—

Group 1 ... Lithium, Sodium, Potassium, Rubidium, Cæsium.
,, 2 ... Copper, Silver, (Gold ?).
,, 3 ... Magnesium, Calcium, Strontium.
,, 4 ... Zinc, Cadmium, Mercury.
,, 5 ... Aluminium, Indium, Thallium.

In the group of lithium, sodium, potassium, the series sequence follows absolutely the chemical sequence. But when we come to the chemical group—calcium, strontium, barium—you find it replaced by a group, magnesium, calcium, strontium, while barium is not used at all. That is a very remarkable departure, and it shows that we have to consider the various conditions which we observe in passing from group to group.

From *group* to *group* with increasing atomic weights the series back towards the violet. Thus, as the limit of a series is represented by the first constant for the first subordinate of the four groups, the limit lies

Between 2858·6 and 1974·3 for Lithium, Sodium, Potassium, Rubidium, Cæsium.
,, 3159·1 ,, 3078·2 ,, Copper, Silver, Gold.
,, 3979·6 ,, 3103·0 ,, Magnesium, Calcium, Strontium.
,, 4294·5 ,, 4015·9 ,, Zinc, Cadmium, Mercury.

In *each group* with the increasing atomic weight the spectrum advances continually towards the red end ; that is, in exactly the opposite direction we observed before.

Having dealt with these details, there are several other general questions which I should like to say a word about, because it is evident that we are here in presence of the beginning of a new attack on the nature of the chemical elements.

Let us attempt to compare these simplest results obtained by this newest form of spectrum analysis, in other words the simplest series, with the earliest stellar forms.

We found that the hottest stars contained hydrogen, helium, and asterium. Well, we have found that those substances have the simplest series ; that is to say, one set of three. I told you that it was more than probable, although it is not absolutely established, that the lithium group of metals is also represented in stars of very high temperature. There, again, we have the simple series of one set of three. About sulphur we do not yet know positively, but it is probable, I think, that sulphur may exist in the hot stars. There, again, we get another simple set of three ; so that for three perfectly certain members of the hottest stars, together with one in all probability and one doubtful, we are dealing with the simplest series in the hottest stars.

But now comes the remarkable fact that side by side with these simple substances we get in the hottest stars magnesium and calcium. We cannot suppose that the absence of the principal series there means a greater simplicity, because I have shown you that only about half the lines in the spectrum of each of these substances has yet been picked up in the series, and if the series represent the vibrations of a single particle, of course the lines which are not represented in the series, by theory must represent the vibrations of some other particles. So that there we are face to face with the possibility of a much greater complexity. Coming a little further down in stellar temperatures we find oxygen, and here we deal with six series instead of three, or two, as in the case of magnesium and calcium ; and even then, as I have pointed out to you, we do not deal with above half the lines of the gas as we can see them at a higher temperature. This, then, seems to suggest that in the hottest stars there are very various stabilities of very various forms. In fact, there seems to be there as here distinctly the survival of the fittest ; otherwise how can we account for the fact that certainly in the hottest stars we get two metals, magnesium and calcium, before we have indication of any other metals, and that where we have those metals and bring our series touch-stone to them we find that instead of being very simple they are really very complex ? However this may be, we are now assured that there is a much greater quantity of some apparently more complex forms in the hotter stars than of the more simple ones ; and that is a matter which the chemists, when they come to inquire into these questions which we are now considering, will certainly have to face. This fact suggests, too, another very interesting question which has some relation, perhaps, to some of those drawings that I have thrown on the screen from Lyell's Elements, which showed that a great many simple organic forms appear in the stratigraphic series at a late period ; that some of the simplest forms died out, others remained. Now, it may be that some of the more simple forms in inorganic evolution, as in organic evolution, really represent later introductions ; but, however this may be, it is perfectly certain that we have not an absolute parallel between the results of the spectroscopic observations of series and the spectroscopic observations of stars. The accompanying table will show very generally how the matter stands. The chief points to refer to are the gaps in the table showing the principal series and the first and second subordinate series. We have the metals arranged in the order of Mendeléjeff's groups. You will observe that after the first metals we practically deal with no principal series at all until we come down at the bottom to oxygen, sulphur and selenium. The same thing happens with the subordinate series so far as the existence of single lines and double lines are concerned. Now, it is a curious point that in the case of several of those substances in which no principal series has been detected, certain lines in the ultraviolet of considerable strength have been observed which may ultimately turn out to represent principal series. Of course, if that should be so it will make the inquiry a very much simpler one than it appears to be at present, and it may possibly break down that terrible amount of uncertainty and irregularity which it has been my duty to point out to you in the series so far examined.

there is no fluting from one end of the spectrum to the other.

Rydberg has suggested that an investigation of the so-called "longest-lines" of the various substances may

	Mendeff. groups.	Atomic weights.	No. of series.	No. of principal series.	Principal series. Single.	Principal series. Double.	Principal series. Triplets.	1st and 2nd subordinate. Single.	1st and 2nd subordinate. Double.	1st and 2nd subordinate. Triplet.	REMARKS.	Per cent. of total number of lines picked up by K. and R.	Per cent. of lines of intensity 10, picked up in series.	Melting points, degrees C.
HYDROGEN	—	1	3	1	—	Double ?	—	—	Double	—	—	100	100	—
HELIUM ...	—	—	3	1	Single	—	—	—	Double	—	In sub. series the double represents strong member with faint companion. Helium really gives a spectrum of six series, but one set of three series has been called Asterium.	100	100	—
ASTERIUM	—	—	3	1	Single	—	—	Single	—	—		100	100	—
LITHIUM	I.	7·0	3	1	—	Double ?	—	—	Double ?	—	—	100	100	180
SODIUM ...		23·0	3	1	—	Double	—	—	Double	—	The pairs in all cases widen as the atomic weights increase.	100	100	90
POTASSIUM		39·0	3	1	—	Double	—	—	Double	—		100	100	58
RUBIDIUM		85·2	1	1	—	Double	—	Not observed				100	100	38
CÆSIUM ...		13·3	1	1	—	Double	—	Not observed				100	100	62
COPPER ...	I.	63·4	2	0	—	—	—	—	Double	—	Each element contains in the ultra-violet a very strong pair of lines which may be principal series.	6	—	1080·5
SILVER ...		107·6	2	0	—	—	—	—	Double	—		26	—	960
GOLD ...		196·7	0	0	—	—	—	—	—	—		?	—	1061·7
MAGNESIUM	II.	24·3	2	0	—	—	—	—	—	Triplets	2852·2 and some pairs not picked up by these series.	64	55	600
CALCIUM		39·9	2	0	—	—	—	—	—	Triplets	Some more triplets and pairs not picked up by these series.	34	17	700
STRONTIUM		87·4	2	0	—	—	—	—	—	Triplets	—	20	7	700
BARIUM ...		136·8	0	0	—	—	—	—	—	—	—	—	—	475
ZINC ...	II.	65·1	2	0	—	—	—	—	—	Triplets	In each case a very strong broad reversed line in the ultra-violet may be principal series.	80	43	410
CADMIUM		111·7	2	0	—	—	—	—	—	Triplets		50	14	320
MERCURY		199·8	2	0	—	—	—	—	—	Triplets		27	12·5	−40
ALUMINIUM	III.	27·0	2	0	—	—	—	—	Double	—	—	—	25	654·5
INDIUM ...		113·7	2	0	—	—	—	—	Double	—	—	—	25	176
THALLIUM		203·7	2	0	—	—	—	—	Double	—	—	—	17	282
TIN	IV.	117·8	0	0	—	—	—	—	—	—	No series have been discovered, but there seem to be groupings of lines which recur very frequently. The lines do not form series.	—	—	232
LEAD ...		206·4	0	0	—	—	—	—	—	—		—	—	326
ARSENIC	V.	74·9	0	0	—	—	—	—	—	—		—	—	450
ANTIMONY		119·6	0	0	—	—	—	—	—	—		—	—	629·5
BISMUTH		207·5	0	0	—	—	—	—	—	—		—	—	270
OXYGEN ...	VI.	15·88	6	(2)	—	—	Triplets	—	—	Triplets		—	—	—
SULPHUR		31·8	3	1	—	—	Triplets	—	—	Triplets	These probably have six series. One strong triplet is observed which may be principal series of second set of three series.	—	—	114
SELENIUM		78·5	3	1	—	—	Triplets	—	—	Triplets		—	—	217

Another matter of considerable importance to us in attempting to arrange the chemical elements along this line of series—and it is work that is sure to be done now that the matter is once started—is to endeavour to see if there is any strict relation between those chemical substances which give us these simple series and those which are more apt to provide us with those exquisite rhythmic flutings. In some of the elements the flutings and the proportions of them from one end of the spectrum to the other are very remarkable, but in other metals the wonderful thing about them is that practically

eventually help us in our inquiries. I will tell you what the longest-line means. If we examine a light source by pointing the spectroscope directly at it, of course the rays from every part of the light source enter the instrument; but if we throw an image of the light source on the slit of the spectroscope, then those particles which exist furthest from the centre will be visible furthest from the image of the centre, and therefore if they are visible enough to give spectra, we should get long lines stretching from the centre to the very limit at which their light is visible enough to be utilised by the instrument. As a matter of fact we do see some very long lines in this way in the case of some substances, and these of course appear to be quite distinct from the shorter lines which are limited to the exact centre of the spark or the arc; to the region, that is, in which the very highest temperature is at work. Rydberg has shown that in a considerable number of cases long lines seem to have a very considerable importance, and on that account it is well worth inquiring into. Rydberg's investigations of the members of the first three groups of the periodic system led him to conclude that the long lines form pairs or triplets, which in the case of each element are characterised by a constant difference (v) in the number of waves of the components. For each group of elements shown in Mendeléjeff's table, this value he finds increases in a ratio somewhat exceeding the *square* of the atomic weight.

What, then, is the general result of our inquiry, taking series in inorganic evolution to represent the cells which are microscopically studied in the case of organic evolution? I think you will agree that the evidence is that, however simple the organic cell may be, the chemical units in the case of any substance represented to us by the movements which are written out by these series must possess different degrees of complexity. I have already told you that a little time ago it was imagined that hydrogen was rendered visible to us by such simple vibrations that only one series of lines could be produced. If that is so, then it looks very much as if whenever we see three series of lines that three molecules or atoms, three different things, are in all probability at work in producing them. When we get six series, that points to a still greater complexity, and when as in the case of oxygen we get six series not accounting for half the lines, then we should be quite justified, I think, in supposing that oxygen was one of the most complex things that we were brought face to face with in our studies of series. When we come to metals where there are no series at all, what do we find? We find that we are dealing with substances with high melting points—that is to say, we cannot bring them down easily to those mobile states represented by the free paths of a permanent gas; and it is quite easy to suppose, on that account alone, that we do not see the vibrations of any of the more simple forms. Therefore, I think it is perfectly certain that we have not universally got down to the equivalent of the cell-level in our study of chemical forms.

With regard to this question of the relation of the two evolutions inorganic and organic, I have still one more diagram which will give an idea of the place of organic evolution in regard to inorganic evolution in the scale of time. I do not want you to pay too much attention to this diagram, because it is entirely hypothetical; but it is constructed on the simplest principles, so that it shall go as little wrong as may be. I begin by drawing a line at the bottom, which represents the zero of temperature; certain temperature values are indicated on the left-hand side of the diagram. Then we have the assumption that a star loses an equal amount of heat in an equal period of time. In that way, then, you see at the bottom we have relative times, as at the side we have temperatures, in Centigrade degrees. Water freezes at a certain temperature above absolute zero, and boils at a certain other point; these are marked on our temperature scale. Then we have to remember that about half-way between the boiling point and the freezing point, all the organic life with which we are familiar on this planet, from the geological evidence and our own experience, must have gone on at a temperature of somewhere about, let us say, from 50° to 40° Centigrade. There, then, we get the limit of organic life in relation to the possible inorganic life, represented by the various chemical changes in the stars. We know from laboratory statements that the stars of lowest temperature are about the same temperature as that of the electric arc, which is about 3500° C., and so we put the Piscian stars there. It has also been stated by Mr. Wilson lately that the temperature of the sun measured by several physical methods is something between 8000° and 9000° C., so that we put there the Arcturian stars. Of course we have no means of determining the temperatures of the hotter stars, so I have ventured to make a very modest supposition that possibly we get about half the difference of temperature between those stars as we have found between the Piscian and the Arcturian stars from experiments on the earth. That will give us roughly something like 5000° C. We find then that if we assume equal increments of temperature for each of the different genera of stars that I brought before you in the second lecture, we get a temperature at the top of the diagram of something like 28,000° Centigrade. All we have to do, then, is to draw a diagonal line on which to mark the various temperatures considered. On this the organic evolution, which represents everything which has taken place with regard to living forms on the surface of our planet from the pre-Laurentian times to our own, is represented by a small dot. It looks, therefore, very much as if these recent results of spectrum analysis, which it has been my duty and my pleasure to bring before you in this course of lectures, may probably be of some value in the future, because they deal with a multitude of changes and a period of time compared with which all the changes discussed by the geologists are almost invisible on a diagram of this size. Not only shall we have probably some help in determining this scale, but I think that, as I have already indicated to you, the wonderful similarity between the substances contained in the organic cell and those which would most likely be free when the greatest amount of chemical combination had taken place on the surface of the cooling world, will throw some light on the basis of organic evolution itself.

In that way, then, we have really been only continuing courses of lectures given here formerly, which had to do with Man's Place in Nature, and with the Sun's Place in Nature; and I think you will agree that we have found fresh grounds for thinking that the more different branches of science are studied and allowed to react on each other, the more the oneness of Nature impresses itself upon the mind.

NOTE ON THE DISCOVERY OF MIOLANIA *AND OF* GLOSSOTHERIUM (NEOMYLODON) *IN PATAGONIA.*[1]

SINCE 1877, when I discovered the Tertiary Mammalian beds of Santa Cruz, in Patagonia, I have been looking for proofs of the ancient connection between the new uplifted lands of the southern part of the American continent and the other lands of the Southern Hemisphere—Africa and Australia. During my subsequent travels in the interior of the Argentine Republic, including Patagonia, my interest in that connection has been increasing, and I have discovered additional evidence, which showed me the former greater extension to the east, in comparatively modern times, of the actual existing lands. The splendid results of the researches made by the La Plata Museum in Patagonia have revealed a greater number of lower forms of vertebrates, including numerous marsupialia, some of which seem to me closely related to the mammals of the Pleistocene fauna of Australia, and among them *Pyrotherium* and *Diprotodon*. I think that my suggestion has an indubit-

[1] By Dr. Francesco P. Moreno, Director of the La Plata Museum.
(This article will appear in the *Geological Magazine* for September 1, and is printed in advance in NATURE, by permission of Dr. H. Woodward, F.R.S.)

able confirmation in the discovery made by the expeditions which I sent in 1897 and in the first months of this year, under the direction of Mr. Santiago Roth, expeditions that have had astonishing results.

In beds containing remains of mammals and dinosaurians, Mr. Roth discovered in 1897 a caudal sheath-ring, very similar to those of the *Glyptodon*, but which I at once recognised as pertaining to a form like the chelonian of the Pleistocene of Queensland, described by Owen. I brought this fossil with me to London for comparison with the remains of *Miolania* preserved in the British Museum (Natural History). The resemblance was great, but the fact of a Tertiary chelonian from Patagonia being analogous to the Pleistocene genus from Queensland and Lord Howe Island was so astonishing that some doubt was permitted; but, having previously ordered a new examination of the fossiliferous bed where the remains were found, I have now the certainty of the extremely close relation between the Australian and Patagonian chelonian. I have received several photographs of a skull discovered by Mr. Roth, which photographs, when compared with the Australian specimens in the British Museum (Natural History), give no place for doubt upon this matter. I think that it is sufficient for the present to give two cuts representing the two forms of *Miolania*. I expect in a few days the original specimen from Patagonia, together with various bones and additional remains of the caudal sheath, with some of the carapace. These will be the subject of a special description by Mr. Arthur Smith Woodward, who has so kindly commenced studies on the fossil reptiles in the La Plata Museum.

I have also brought with me to London a piece of a skin discovered in a cave near Last Hope Inlet (lat. S. 51° 30′), which I have referred to a species of the extinct *Mylodon* (see "On a Portion of Mammalian Skin, named *Neomylodon listai*, from a Cavern near Consuelo Cove, Last Hope Inlet, Patagonia," by Dr. F. P. Moreno; with a description of the specimen by A. Smith Woodward); while Mr. Ameghino has announced that another piece of the same skin pertains to a mammal still living, of small size, which he has called *Neomylodon*. When I took this piece at Last Hope Inlet in November 1898, I was convinced that it was part of the skin of a *Mylodon* or a form very similar to it, and that the discovery was of great importance to me, as I think that the Pampean muds, where the extinct Edentata are found, are of very modern age; an opinion contrary to that held by another observer, Mr. Ameghino, who refers the Pampean fauna to the Tertiary age. I have already maintained that the extinction of the greater part of the Pampean fauna took place after the presence of man in a relatively advanced culture, called Neolithic culture. Having, then, great interest in the continuation of the investigations in the cave, I ordered, before coming to London, more extensive researches, and these have been made with very successful results.

Dr. Otto Nordenskjöld had previously obtained in 1896 a piece of the same skin, which, it is known, was discovered by a party of Argentine surveyors during the preliminary studies for the boundary between Argentina and Chili in the Andean Cordillera, and, recognising also the importance of it, Dr. Erland Nordenskjöld went last year to the same spot to look for some more remains. The excavations which he made gave him, so far as I know, some bones, pieces of jaws, teeth, and claws of the same animal, but he did not obtain more remains of the skin.[1] My assistant, Mr. Hauthal, arrived later at the cave, when Dr. Erland Nordenskjöld had terminated his researches and commenced further exploration. He obtained, not only skulls, jaws, teeth, bones and claws, but also a nearly complete skin of the animal, which shows that it is a *Glossotherium*, together with bones of *Macrauchenia*, *Equus*, and *Auchenia*, also a great quantity of dung, hay cut by man, ashes, and some bones worked by man. I am not yet sure if the bones of man discovered by Mr. Hauthal were found in the same cave or in one of those in its neighbourhood; but the presence in the *Glossotherium* deposit of bones worked by man is a proof that man and other mammals, whose remains have been discovered in the cave, were contemporary. I suggest that the skin has been preserved by man for bedding. In the caves inhabited by ancient man in Patagonia I have seen cut hay, and probably this also was used for beds.

B. A.

FIG. 1.—A, front view of skull; and B, side view of tail-sheath, of *Miolania Oweni* (greatly reduced in size) from Pleistocene deposits, Queensland, Australia [originally described as *Megalania prisca* by Owen in 1880].

I expect to receive in a few days all these specimens at the same time as those of the *Miolania*, together with reports on the discoveries, and I think they will arrive in time for me to exhibit these remains at the meeting of the British Association at Dover.

The discovery made by Mr. Roth of some advanced Mammalia in the beds that contain dinosaurians, and Mr. Hauthal's discovery of remains of extinct vertebrates and other mammals in the caves of Southern Patagonia, associated with *Macrauchenia*, *Equus*, *Auchenia*, and man, are proofs of the very recent changes in the physical geography of Patagonia, and afford most interesting problems, which can only be solved by a systematic examination of the Argentine country by experienced geologists. In the course of my paper on Patagonia, read before the Royal Geographical Society (May 29), I proposed that this Society, the Royal Society, and the British Museum, with other scientific institutions, should proceed to carry out these necessary investigations. These problems are not extraneous to the explorations which may be carried out by an Antarctic

FIG. 2.—Reproduction of a photograph of the front view of skull, with the lower jaw, of *Miolania*, obtained in 1899, from Patagonia, by Mr. Santiago Roth, of the La Plata Museum, Argentine Republic (greatly reduced in size).

[1] "E. Nordenskjöld, Neue Untersuchungen über *Neomylodon listai*, Zool. Anzeiger," vol. xxii. (1899) pp. 335–336.

expedition, and I think the new discoveries which I now communicate to the *Geological Magazine* may urge on the despatch of such expeditions as I propose. If these expeditions be made, how many changes may be produced in actual and general ideas on the age of the South American fossiliferous strata, on the disappearance of the lost southern lands, and on the affinities of extinct faunas so distant in time and space as those of South America and Australia!

MR. JOHN CORDEAUX.

BY the death of Mr. John Cordeaux, ornithology loses, not only one of its most ardent votaries, but one who had pursued, if he did not strike out for himself, a line very different from that taken by most British lovers of birds. For nearly six-and-thirty years, as shown by a long series of contributions, chiefly to *The Zoologist*, he applied himself to the study of the phenomena of bird-migration, at first as exhibited on the coasts of Lincolnshire (in which county he lived) and Yorkshire. This led him in the autumn of 1874 to go to Heligoland for the sake of comparing notes with the now well-known Herr Gätke, whom, it is believed, he was the first British ornithologist to visit; and he soon after wrote for *The Ibis* (1875, pp. 172-188) a notice of the very wonderful collection formed by that naturalist on that island. In 1879 he joined Mr. Harvie-Brown (who had just communicated a remarkable paper to the Natural History Society of Glasgow) in a successful attempt to procure observations on migrating birds from the keepers of lighthouses and lightships on the coasts of England and Scotland; and in the following year, when the results of their inquiry were brought before the British Association at the Swansea meeting, he was named secretary of a committee appointed to continue systematically the scheme which they had shown to be practicable. Of this committee, which (with a slight variation of title) has since been annually reappointed, he has always been the hardworking secretary, and it is not too much to say that nearly all its success is mainly due to him. He not only arranged with the authorities for the distribution of the schedules, instructions, and other information necessary for the observers, but, by his own efforts, raised by subscription a large sum of money to meet the expenses of the inquiry, which proved to be far greater than had originally been anticipated. The time and trouble which all this involved were at first enormous; and, even to the last, the correspondence which he had to carry on was immense, yet his services were as willingly rendered as though he had been handsomely paid for them, instead of giving them gratuitously, and the way in which he contrived to interest the men at the lighthouses and lightships in the undertaking was marvellous. The results of this labour, continued without intermission for nine years, were partly shown by the admirable "Digest of the Observations," made by Mr. W. Eagle Clarke, which the committee was able to include in its report presented to the Association at Liverpool in 1896; and, as has been announced, that gentleman is still occupied in working out further details from the mass of materials that has been collected.

Mr. Cordeaux made more than one visit to Heligoland, and is understood to have been instrumental in bringing about the publication of an English translation of Gätke's celebrated work, though never committing himself to the adoption of his friend's views on many points. Indeed, he abstained on principle as much as possible from advocating any theories on the subject of migration, being convinced that much more knowledge had to be acquired from observation before more than a few first principles could be safely accepted. That he was the life and soul of the Migration Committee is beyond all doubt. His happy tact and sanguine temperament overcame all difficulties, though—especially from the financial point of view—they were at times so formidable as to threaten the abandonment of the work; yet by his care funds were always found to carry it on, eking out the successive and by no means illiberal grants of the British Association. He is said to have been very successful as a lecturer, and he often lectured on some ornithological subject, especially on the migration of birds, in the towns of Yorkshire and other parts of the country.

Forty papers are credited to Mr. Cordeaux in the Royal Society's Catalogue up to 1883, a number which might possibly be doubled now, and in addition to these he was the author of an unassuming but well-written little book, "Birds of the Humber District," published in 1872, a new edition of which it had been his intention to bring out. He died, after a short illness, at his residence, Great Cotes House, in Lincolnshire, on August 1, in the sixty-ninth year of his age, deeply lamented by all who had been associated with him in the work he so indefatigably carried out.

A. N.

NOTES.

WE much regret to record that the serious illness of Prof. R. W. Bunsen, referred to in last week's NATURE, has ended fatally. An account of the chief work of this world-renowned chemist appeared nearly twenty years ago in our Series of Science Worthies (vol. xxiii.), and we hope to publish a further appreciation of the deceased investigator next week.

THE funeral of Sir Edward Frankland took place at Reigate on Tuesday. There were present, in addition to the immediate relatives, Sir Frederick Bramwell, Lord Lister, Sir Henry Roscoe, Sir Myles Fenton, Sir Michael Foster, Dr. Ludwig Mond, Dr. Thorpe, and others. The Rev. Prof. Bonney conducted the funeral service. Many wreaths adorned the coffin, including one from the Fellows of the Institute of Chemistry and one from the Chemical Society.

MAJOR RONALD ROSS, the leader of the expedition sent to Sierra Leone by the Liverpool School of Tropical Diseases to investigate the possibility of exterminating the malaria-bearing mosquito, has sent to Liverpool the following cablegram: "Malarial mosquito found. Ask Government to send at once men." Major Ross's observations in India indicated that the malaria parasite is borne by the spotted-winged mosquitoes, and not by the common brindled or grey mosquitoes; and his message announces that he has found that malaria on the West Coast of Africa is produced under the same conditions as in India. There is evidence that the malaria-bearing species only breeds in small isolated collections of water which can be easily dissipated, but the expedition has not yet had time to verify this point.

THE presence of bubonic plague in Portugal has been officially notified to the Local Government Board. Oporto has been declared to be infected, and the other ports of Portugal are considered suspected. Port sanitary authorities in this country have been instructed in the precautions to be observed to prevent the introduction or spread of the disease here.

IT is announced that Sir Edmund Antrobus is desirous of selling Stonehenge, the famous and mysterious monument on Salisbury Plain. Thinking it right that the nation should have the opportunity of purchasing this great relic of antiquity, the owner has offered it to the Government, with about 1300 acres of surrounding land (subject to certain pasturage and sporting rights), for the sum of 125,000*l*.

PROF. GEORGE FORBES, F.R.S., has just visited the Niagara Falls Company, and he describes in the *Times* the remarkable success which the Company has attained in the use of the Falls to develop electric energy. An enormous number of factories has been established on the Company's land, and they use between them no less than 34,590 horse-power. Additions are to be made in October, and two new works, the Atchison Graphite Company and the Lead Reduction Company (Litharge), will be supplied, bringing the total up to 45,190 horse-power contracted for, with an income of over 150,000*l.* The operating expenses do not exceed 25,000*l.* per annum. The result indicates, among other matters, the strides which have been taken of late years in electro-chemical and metallurgical processes. With regard to the machinery, the dynamos, which were totally new, not only in size but in their general design, never give the slightest trouble; and the transformers, ranging up to 2500 horse-power, have answered their purpose perfectly, even with the low frequency of alternations, which was generally condemned when Prof. Forbes introduced it, but is recognised now by every one at Niagara as contributing largely to the success of the scheme.

THE Wellman Polar expedition, which left Tromsö, Norway, on June 26, 1898, returned there from Franz Josef Land on August 17, on the s.s. *Capella*, which took the party on board at Cape Tegetthof. Mr. Walter Wellman's intention was to make a rush to the North Pole. According to the Reuter telegram received on Saturday last, an outpost was established as far north as latitude 81°, and two men were left in it to spend the winter, while the main party returned to Cape Tegetthof (lat. 80°). In the middle of February last, in the depth of winter, Mr. Wellman, with three Norwegians and forty-five dogs, started northwards. On reaching the outpost the two men were found, but one had been dead for two months. Pushing northwards the party discovered land north of the Freeden Islands, where Nansen landed in 1895. In the middle of March, when all hands were confident of reaching latitude 87° or 88°, if not the Pole itself, Mr. Wellman, while leading the party, fell into a snow-covered crevasse, seriously injuring his leg, and the party was therefore compelled to retreat. Two days later they were roused at midnight by an earthquake, and in a few moments many dogs were crushed and sledges destroyed. Mr. Wellman's condition became alarming on account o of inflammation, but his companions dragged him on a sledge, making forced marches for nearly 200 miles to the headquarters of the expedition, where they arrived early in April. The *Capella* arrived at Cape Tegetthof on July 27, and sailed homeward with the party on August 10. Though the expedition has thus ended in failure so far as reaching the North Pole is concerned, it is stated that important scientific observations have been made by Dr. Hoffmann (naturalist), Mr. Harlan (physicist), and Mr. W. B. Baldwin, of the U.S. Weather Bureau, who accompanied the expedition as meteorologist and second in command.

PROF. BALBIANI has just died at Meudon at the age of seventy-five years. The following particulars of his career are given in the *Lancet:* As Professor of Comparative Embryology at the College of France he was formerly assistant to Claude Bernard at the Museum. Although descended from an Italian family he was born at Havana, and pursued his medical studies at Frankfort-on-the-Main before going to Paris. His reputation was world-wide, and he leaves a considerable number of works, of which the best known deal with the constitution of the egg, the embryonic vesicle, cellular division, the reproductive process in infusoria and aphides, and silkworm disease. He had been many times a laureate of the Institute, but, despite most pressing invitations on all hands, he never presented himself as a candidate at the Institute or Academy of Medicine, where he would certainly have been elected. He wished only to be a member of the Society of Biology, of which he was one of the oldest and most industrious members. Besides, for many years past he did not himself lecture, but devoted his time more and more exclusively to the laboratory, leaving his lecture work to his assistant, Dr. Hennegy. Prof. Balbiani was, with Prof. Ranvier, editor of the *Archives d'Anatomie Microscopique.*

THE *Times* correspondent at St. Petersburg announces that a new regulation on Russian weights and measures was officially published on August 18. The Russian pound is fixed as the standard of mass and declared to be equal to 409·512 grams, a pail or vedro is to hold 30 pounds of distilled water at 16°·6 C., and a garnietz 8 pounds of water. The unit of length is the arshin, equal to 71·12 centimetres. The metric system is to be optional, and may be used with the Russian in commerce in dealing with contracts, accounts, &c., and after mutual agreement by State and municipal authorities. Private persons are, however, to be under no compulsion to use the metric system when dealing with the above-named authorities.

THE *Scientific American* states that the creation of a great national forestry and game preserve in northern Minnesota, embracing 7,000,000 acres around the headwaters of the Mississippi River, with many lakes of rare beauty, well stocked with fish, will be advocated before the U.S. Congress next winter by prominent citizens of Chicago and Minnesota. It is believed that the promoters of the plan will not experience much difficulty in interesting Congress. The game and the virgin forests of the United States are disappearing so rapidly that it is exceedingly important that measures be taken, before it is too late, to save some of the great wooded areas of the continent.

UNDER the auspices of the Philadelphia Commercial Museum and the Franklin Institute, a National Export Exposition for the advancement of American manufactures and the extension of the export trade will be held from September 14 to November 30. At the end of last year the U.S. Congress voted 350,000 dollars in support of the exposition, and other funds, amounting to 100,000 dollars, have been provided by the City Councils of Philadelphia and private subscriptions. The exposition grounds comprise a tract of land, fifty-six acres in extent, granted to the Philadelphia museums by the city of Philadelphia, and another tract of six acres secured for the uses of the exposition. Of the five structures comprising the main exhibition buildings three are permanent, but will only be completed at the present time sufficiently for the purposes of the exposition. These three permanent pavilions will have two stories. They will each be 380 feet long and 90 feet wide. The space between them will be covered by temporary buildings connected with the pavilions, the whole forming a single harmonious edifice. The permanent buildings will eventually become the home of the Philadelphia museums. One of the chief events to take place in connection with the exposition will be the International Industrial and Commercial Congress, which will assemble in Philadelpnia, beginning on October 10. A number of foreign Governments have accepted the invitation to send official envoys, and almost every city of the United States and Canada with a population over 10,000 will be represented by delegates from their Boards of Trade, Chambers of Commerce, &c. Of special interest to the members of the Franklin Institute will be the ceremonies in commemoration of the seventy-fifth anniversary of the Society, which will be held in one of the exposition buildings. The arrangements for this event contemplate a series of commemorative meetings, beginning Monday evening, October 2, and occupying the entire week. The evenings of the week will be occupied successively by the Sections in the order of seniority, beginning with the Chemical Section.

A SERIES of six articles "by a Contributor," which appeared in the *Banffshire Journal*, has been reprinted as a pamphlet entitled "Prof. McIntosh on Trawling and Trawling Investigations: a criticism and analysis." It is written with evident detailed knowledge of the work of the Scottish Fishery Board, and of fishery matters in general. Prof. McIntosh's tables and statistics are carefully analysed—the object being to show that the conclusions in his book, "The Resources of the Sea," are invalidated by the errors which have crept in in the transcribing and re-arranging of an enormous mass of figures from the Annual Reports of the Fishery Board. The matter in dispute is of such importance that the Fishery Board for Scotland in their next report should definitely and authoritatively state whether or not they accept Prof. McIntosh's statements as to the results of the trawling experiments off the Scottish coast, and, if not, what grounds they have for arriving at a different conclusion.

THE Meteorological Council have published a valuable contribution to maritime meteorology, viz. Meteorological Charts of the Southern Ocean between the Cape of Good Hope and New Zealand. The region embraces latitude 30° to 60° S. and longitude 10° to 180° E., and the charts show, for each month of the year, the wind direction and force for areas of 3° of latitude by 10° of longitude, the barometrical pressure by isobars, temperature of air and sea by isotherms, and ocean currents, in addition to other useful data. The publication will add considerably to the information hitherto available for this part of the ocean, and will therefore be very serviceable to navigators. Introductory remarks draw attention to all the leading results shown by the charts, and to the broad features of the distribution of barometric systems and of air and sea temperature. In the preparation of this work, observations for each four hours have been extracted from about 2450 logs kept for the Meteorological Office or on board H.M. ships, being all that were available between the years 1855 and 1895, and also from numerous logs of private shipping companies.

"SYMONS's British Rainfall" (Stanford) for 1898 contains not only the usual statistics and conclusions referring to the distribution of rain over the British Isles last year, but also several articles of general meteorological interest. Thirty-five self-recording rain gauges have been described in previous volumes, and eight more are described in the present report, several of them being illustrated by diagrams showing the principles of construction. In an interesting note Mr. Symons tests the general proposition that the annual rainfall increases with the elevation of the locality above the sea, by applying it to the English lake district. The highest station considered was at Sca Fell Pike (3200 feet), and the lowest Greenside Mine (1000 feet). Grouping the stations according to altitude in zones differing by 500 feet, no sign of increase or decrease of rainfall with altitude was found—in fact, the lowest group (1000-1499 feet) and the highest (3000 upwards) had identical annual precipitations, viz. 99·3 inches. Moreover, the rainfall at twenty-nine stations having annual amounts of 100 inches or more were arranged according to precipitation, but little evidence was afforded of an increase with elevation, and many of the results point to a conflicting conclusion. For instance, Seathwaite (altitude 422 feet) has an annual rainfall of 135 inches, while at Seatoller Common (2000 feet) the fall is 126 inches; Dungeon Gill and Ullscarf have both the same fall, though the altitude of the former is 311 feet, while that of the latter is 2100 feet. Mr. Symons concludes: "All these cases show that altitude alone has little influence on the amount of rainfall, and that in a mountainous country attention should chiefly be directed to the trend of the hills and valleys in relation to the rain-bearing winds."

DR. HERGESELL, of Strassburg, has contributed to the *Illustrated Aeronautical Magazine* (No. 4, *Jahrgang* 1899) a mathematical investigation of the theoretical vertical movements of a free balloon. The subject engaged the attention of Mr. J. Glaisher in the *Encyclopaedia Britannica*, and is of considerable interest for scientific balloon navigation. The first case considered is that of the ascent of an imperfectly inflated balloon, and the formulæ give the velocity attained in a stratum of air of a definite density, *i.e.* at a definite altitude, and the time required in reaching this stratum. In the case of a perfectly inflated balloon, the investigation shows that the maximum height that can be attained depends entirely upon the lifting power, and that it is independent of the velocity of ascent, and of the resistance of the air. In the case of the descent of a balloon, it is shown that the velocity of the fall does not continually increase, as is often stated, but, on the contrary, decreases, and that there is no danger in allowing the balloon to descend from a great altitude without throwing out ballast, as the velocity of the descent decreases according to the greater height from which the descent is made.

M. J. LIPPMANN, writing in the *Journal de Physique* for August, proposes the adoption of an absolute measure of time based on the Newtonian constant of gravitation. The possibility of establishing such a unit depends on the property that the Newtonian constant is independent of the units of length and mass, and is of minus two dimensions in time; hence, by making the constant of gravitation equal to unity, an absolute unit of time is obtained which is found to be equal to 3862 seconds of mean time approximately. The afore-mentioned property, however, involves the assumption that the unit of mass is of the same dimensions as the unit of volume; in other words, that density is of no dimensions. Strictly speaking, M. Lippmann's time unit is of $-\frac{1}{2}$ dimensions in density, and therefore its value depends on the nature of the standard substance chosen as the unit of density. The proposal practically amounts to this: instead of adopting an astronomical unit of density (corresponding to the astronomical unit of mass) based on taking the mean solar second as unit of time, we are to adopt an absolute unit of time based on taking water as the unit of density.

THE *Atti dei Lincei* contains in recent numbers two somewhat closely allied papers on thermo-electricity. The first of these is a verification of the principle of thermodynamic equivalence for bimetallic conductors, by Signor Paolo Straneo, who concludes not only that thermo-electric phenomena proceed regularly in perfect accordance with theory, but that they can be studied with sufficient exactness by temperature-observations without having recourse to calorimetry. The determination of the Peltier-effect coefficient by the author's method succeeds even in the case in which previous methods are wanting in accuracy, namely, when the two metals possess a high specific resistance and a feeble Peltier-effect. With the present method, the Joule effect only slightly affects the phenomenon under consideration.

SIGNOR STRANEO's method forms the basis of a paper by Signor A. Pochettino on variations of the Peltier-effect in a magnetic field. The value of the Peltier-effect coefficient was observed to vary with the magnetisation. In Signor Pochettino's experiments, it increased up to a maximum value of 0·008968, corresponding to a field of ninety-eight units, and then decreased, reaching its normal value (0·008824) in a field of about 345 units, and continuing to decrease as the intensity of the field was further increased. The formula deduced from Houllevigue's experiments, combined with Thomson's formula, only represents the phenomenon up to a field of 700 units. Lastly, the variation of the Peltier-effect coefficient is independent of the direction of magnetisation; in fact, in suitably-arranged experiments it is found that when the stationary temperature is attained, no changes take place in the thermal conditions of the conductors when the magnetising current is reversed.

IN a report received by the Foreign Office, Sir William Garstin has called attention to the need for a scientific examination of the Sudan, with a view to the development of its natural resources. It is pointed out that a very possible source of future wealth to the Sudan lies in the vast forests which line the banks of the Upper Blue Nile and extend, in an easterly direction, to the Abyssinian frontier. In the Bahr-el-Ghazal province also, particularly in the Bongo country, large forest tracts exist. The ebony tree (*Dalbergia melanoxylon*) is met with south of Karkauj, on the Blue Nile, and again in the vicinity of the Sobat River. On the White Nile, in the Bongo and Rohl districts, the india-rubber creeper (*Landolphia florida*) is found in great profusion. If the rubber yielded by this creeper be not of quite so good a quality as that obtained from the Assam india-rubber tree (*Ficus elastica*), it is still of sufficient value to be counted as an important asset in the future trade of the Sudan. The Assam india-rubber tree should certainly flourish well in most parts of the Sudan, more particularly south of Khartoum. Although this tree takes from twenty to thirty years to arrive at a girth sufficient to permit of regular tapping, its yield is so valuable (about 3*l.* per tree per annum) that its introduction into the country is well worth attempting. It is very much to be hoped that a scientific examination of the Sudan forests may ere long be carried out under the superintendence of an expert. It is certain that much valuable information would be obtained from his report. Very little is known regarding the possibilities of mineral wealth in the Sudan. Until the country is more settled, an investigation of the mountainous regions of Kordofan and Darfur on the west, and of the Abyssinian frontier on the east, would be impossible. Iron ore is found in the Bahr-el-Ghazal province, and also in Darfur; while gold mines were at one time worked in the mountains south of Fazogl. Could coal be discovered, it would make a great change in the whole question of the Sudan. In a few years' time it is probable that the Geological Survey Department of Egypt will be able to depute parties to examine the Sudan. For the present, Sir William Garstin thinks nothing can be done.

"VARIATION and Sexual Selection in Man" is the title of a paper by E. Tenney Brewster in the *Proceedings* of the Boston Society of Natural History (vol. xxix., 1899, p. 45). The author offers evidence to prove that *conspicuous dimensions tend to be more variable than other dimensions*. Not only is the face more variable than the head, but the nose should be more variable than the head; the face without the nose should be more variable than the head; and the nose should be more variable than the rest of the face. The author also suggests that sexual selection has brought it about that parts of the body tend to be more variable in proportion as they are of greater æsthetic value.

THE Report of the South African Museum for 1898, issued as a Parliamentary Paper, by the Director, Mr. W. L. Sclater, is satisfactory reading. It appears that in all departments the collections are steadily increasing; while great attention is being paid to the proper exhibition of suitable specimens. In the Geological Department a good collection of the rocks of the Kimberley mining district is already displayed; and steps are being taken for the formation of a complete collection of the economic mineral products of South Africa. This is as it should be; and it is equally satisfactory to learn that the Director is fully alive to the necessity of procuring specimens of all the larger mammals before it is too late. The collection of South African antelopes is indeed complete, with the exception of the Gemsbok and Lichi; and specimens of these ought not to be difficult to procure. It may be hoped that, in addition to the mounted specimens, a study series (if possible in duplicate) of skins may likewise be procured. The only subject the Director has to regret is that he has been unable, chiefly from lack of funds, to continue the work of preparing popular descriptive labels for the exhibited specimens. The hope is, however, expressed that the work may be shortly resumed.

AS an excellent bit of work on the local distribution of a species, attention may be directed to Dr. N. H. Alcock's history of the Hairy-armed Bat in Ireland, published in the August number of the *Irish Naturalist*. In England this Bat is found rather abundantly along the Avon valley in Warwickshire, Worcestershire and Gloucestershire; it occurs rarely in Yorkshire, and has been recorded from Cheshire. In Ireland it has been found in most of the north-eastern counties, but nowhere else. We now want to know the reason of this very local distribution; and until this is ascertained our task is but half done.

M. E. PITARD describes in *l'Anthropologie* (x., 1899, p. 281) three crania from Swiss Lake sites. The first from Point, with an index of 91·5, belongs to the Rhetian or Dissentis type, and is remarkably similar to a skull described by M. Verneau from Concise, which that author believed to belong to the Bronze Age; but M. Pitard asserts that his example is Neolithic. The other two crania were found in the same layer at Concise, and are of the Bronze Age; their indices are 77·6 and 84·6.

THE Vaï or Vei are the only negroes who possess a true and indigenous writing. They occupy a territory on the confines of Sierra Leone and Liberia. The alphabet is syllabic, and it is the only syllabic alphabet existing in Africa. The first account of this remarkable language was published by Forbes and Norris in 1849, and Koelle also wrote on it in 1849 and 1854. Since then nothing has been published thereon till the recent study of M. M. Delafosse (*l'Anthropologie*, Tome x., 1899, pp. 129, 294). Forbes and Koelle asserted that the alphabet was invented about 1829 or 1839, but Delafosse considers it at least two hundred years old and perhaps older; it is not even certain that it was invented by the Vaïs themselves. Forbes was also wrong in stating that this alphabet was no longer in use in 1849; as a matter of fact, it is still increasingly employed. Of the 226 characters in the alphabet, 25 resemble Berber consonants in form, and 20 resemble European letters and numerals; but these may be purely superficial resemblances, as the sounds do not correspond: the author does not consider that the Vaï alphabet has been derived from these sources.

SIR J. BURDON-SANDERSON asks us to notify the following errata in his MS. of the abstract of the Croonian Lecture published in NATURE of August 10. On p. 344, col. 1, line 5, for "Fig. 1" read "Fig. 2"; col. 1, line 18, for "Fig. 2" read "Fig. 1"; col. 2, line 12 from the bottom, for "60" read "40."

PART XV. of Mr. Oswin A. J. Lee's elaborate work, entitled "Among British Birds in their Nesting Haunts," has been published by Mr. David Douglas, Edinburgh. The Part contains ten beautiful plates, illustrating the nesting places and nests of the whinchat, osprey, storm petrel, yellow bunting, rook pigeon, Manx shearwater, grey wagtail, and red grouse.

HERR EUGEN VON CHOLNOKY contributes to the *Verhandlungen der Gesellschaft für Erdkunde* a short summary of the scientific results of his journeys in China and Manchuria during 1896–98. The most important contributions refer to the geology of the regions visited, and in particular to the positions of the great lines of faulting crossing Manchuria, indicated by Richthofen.

THE current number of the *Zeitschrift der Gesellschaft für Erdkunde* (vol. xxxiv, No. 2) is entirely devoted to the official reports of the members of the German deep-sea expedition in the *Valdivia*. Prof. Chun gives a narrative of the expedition and its progress; Dr. Gerhard Schott reports on the oceanographical work; and the navigating officer, Herr Walter Sachse, adds an account of the re-discovery of Bouvet Island. A summary of the contents of these reports has already appeared in these columns (p. 114).

A NUMBER of students from the Paris École Supérieure d'Électricité visited electrical works and manufactories in Switzerland at the end of last March, this being the second excursion arranged by the authorities of the School. A report upon some of the objects and installations examined was presented to the Société internationale des Électriciens in May, and has just been published as an excerpt from the *Bulletin* of the Society, by M. Gauthier-Villars, Paris.

THE additions to the Zoological Society's Gardens during the past week include a Vervet Monkey (*Cercopithecus lalandii*) from South Africa, presented by Mr. R. Hilliard; a Brown Capuchin (*Cebus fatuellus*, ♀) from Guiana, presented by Colonel Bourchier; a Common Kingfisher (*Alcedo ispida*), British, presented by Mr. John Porter; an Alexandrine Parrakeet (*Palaeornis alexandri*, ♀) from India, presented by Miss J. M. Pott; a Common Boa (*Boa constrictor*) from South America, presented by Mr. C. W. Lilley; an Alligator (*Alligator mississippiensis*) from Southern North America, presented by Commander H. Woodcock; two Grevy's Zebras (*Equus grevyi*, ♂ ♀) from Southern Abyssinia, a Malayan Bear (*Ursus malayanus*) from Malacca, deposited; three Pink-headed Ducks (*Rhodonessa caryophyllacea*, ♂ ♀ ♀) from India, six Edible Frogs (*Rana esculenta*), European; twelve Paradise Fish (*Macropus viridi-auratus*) from China, purchased; a Japanese Deer (*Cervus sika*), a Puma (*Felis concolor*), a Burchell's Zebra (*Equus burchelli*, ♀), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

HOLMES' COMET 1899 *d* (1892 III.).—

Ephemeris for 12h. Greenwich Mean Time.

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br. r^{-2}	Br. $(r\Delta)^{-2}$
August 24	2 57 44·22	+38 17 15·7	0·1888	0·04999
25	58 33·92	38 32 21·3		
26	2 59 22·11	38 47 22·9		
27	3 0 8·77	39 2 20·4		
28	0 53·85	39 17 13·7	0·1869	0·05109
29	1 37·31	39 32 2·7		
30	2 19·13	39 46 47·1		
31	3 2 59·26	+40 1 26·8		

During the ensuing week the comet is in a good position for observation by observers having sufficient optical power; it passes closely to the south of the second magnitude variable star β Persei (Algol).

THE PARIS OBSERVATORY.—The annual report of M. Lœwy, the director of the Observatory, contains a detailed review of the work accomplished during the past year.

Special attention has been devoted to the improvement of meridian observations, chiefly in the attempt to eliminate instrumental errors by greater precision and stability of the mountings.

The small equatoral coudé has been provided with several accessories, and the building covering it so altered that the whole is now adapted for astrophysical observations.

The volume of observations made during 1897 will shortly be published in four separate parts, by different authors, who will each be responsible for all reductions, descriptions and discussions contained in the part under their names.

The fourth part of the Paris Observatory Catalogue (of which the first three parts already published contain all the meridian observations made from 1837–1881) has just been completed. The meridian circles have been in use for fundamental observations, for a revision of Lalande's Catalogue, and for work on the variation of latitude.

Coudé Equatorial.—The large instrument has been chiefly used in obtaining further series of photographs of the moon (scale about 6·5 inches to the lunar diameter) for the large lunar atlas now in progress of publication. During the year 591 plates have been obtained for this purpose. The method of enlargement of the negatives has also been improved.

Accompanying the report is a heliogravure of the moon when 20d. 5·9h. old, reproduced the same size as the original plate.

For part of the year the photographic objective was replaced by the visual glass, and the instrument then used by M. Hamy for measuring the diameters of small celestial objects by an interference method. The satellites of Jupiter and the planet Vesta have been measured in this way, the diameter of the latter agreeing very closely with the value obtained by Prof. E. E. Barnard.

Astrographic Equatorial.—The actual photographic work is now almost completed, all that remains to be done being the replacement of a small number of defective plates. The reduction of the plates for the Catalogue is well in hand, and seven of the Chart plates have been engraved for heliographic reproduction.

"THE BULLETIN ASTRONOMIQUE."—The August number contains several interesting and suggestive articles.—M. Flammarion contributes an article on "The World of Jupiter," in which he discusses at length the question of the various rotation periods of the planet, and also an illustrated account of the observation made by M. Antoniadi at Juvisy during the opposition of June 1898.—"The Rotation of Venus" is treated mathematically by Abbé Th. Moreux, based on observations made at Juvisy by M. Antoniadi.—"Observations of Mars" (illustrated) are contributed by MM. V. Cerulli and J. Chloudoff.—MM. L. Rudaux and Em. Touchet furnish an article on the "Systematic Observation of Meteors," giving a suggested form for recording observations systematically, and dealing with the determination of radiants, the physical characters of the swarms, heights of the meteors, and the photographing of them.

THE SUN'S HEAT.—Prof. T. J. J. See contributes a further article dealing with the extension of Helmholtz's theory of the heat of the sun, in *Astr. Nach.* (Bd. 150, No. 3586). The method he now pursues is the determination of the potential of a heterogeneous sphere as caused by itself. He finds that the energy developed by the condensation on this assumption is greater than that produced in the condensation of a homogeneous sphere in the ratio of 176,868 to 100,000.

IRON AND STEEL INSTITUTE.

THE autumn meeting of the Iron and Steel Institute was held this year at Manchester, on August 15 and 16, under the presidency of Sir William Roberts-Austen, K.C.B., and was attended by an unusually large number of members. The meetings were held in the Town Hall, the members being welcomed to Manchester in eloquent speeches by the Lord Mayor and by Mr. S. R. Platt, chairman of the Executive Reception Committee. In acknowledging the words of welcome, the President referred to the services rendered to metallurgy by Dalton and Joule, and by such great engineers as Fairbairn, Whitworth and Daniel Adamson, Manchester's distinguished sons. The programme was a long and varied one, no less than ten papers being on the list. The first read was by Prof. J. Wiborgh, of Stockholm, whose contribution, which was translated and read by Mr. H. Bauerman, dealt with the use of finely divided iron ore obtained by concentrating processes. By the introduction of such methods of separation, the power of enriching iron ores has been greatly increased; but the advantages are qualified by the circumstance that the product obtained is usually in the form of fine powder, which limits its utility to the smelter. The question of how such material can best be applied is one of importance, and the author shows how the material may be utilised by direct addition to the charges in the blast furnace, by agglomeration previously to charging in the blast furnace, as a refining or softening material in the open-hearth furnace, and for the production of sponge iron for use in the open-hearth furnace.

Mr. H. C. McNeill next read a lengthy paper on some forms of magnetic separators and their application to different ores. The machines described were those invented by Wenström, by Delvik-Gröndal, by Heberle, and by Wetherill and the Monarch separator. Results obtained in practice in Sweden were discussed, and numerous illustrations were given. In the discussion of these two papers valuable remarks were made by Mr. James Riley, Mr. G. J. Snelus, F.R.S., Sir Lowthian Bell, Mr. Stead and others.

A new casting machine for blast furnaces was then described by Mr. R. H. Wainford. It is an ingenious apparatus for casting sandless pig iron in insulated moulds, so as to maintain a good crystalline fracture, equal to that of the pig iron made in sand beds, at a reduced cost of production. The advantages and disadvantages of this apparatus were discussed by Mr. E. Windsor-Richards, Mr. W. Hawdon, Mr. Cooper and Sir Lowthian Bell.

Mr. Syed Ali Bilgrami, Secretary to H.H. the Nizam's Government Public Works Department, Railways and Mines, then read a paper on the iron industry in Hyderabad. He described the geological structure of the Nizam's territory, and the various iron ore deposits met with.

Some interesting facts were brought forward by Major R. H. Mahon, of Cossipore, relating to the possibility of manufacturing at a profit iron and steel in India. In the absence of the author this paper was read by the Secretary, Mr. Bennett H. Brough. An interesting discussion followed, in which Mr. Bauerman and Mr. R. Price-Williams took part. The meeting was then adjourned until Wednesday, when a paper by Mr. C. H. Ridsdale was read. The microscopic examination of steel is a subject on which a good deal has been written during the last few years. Most of the papers hitherto published have dealt with the matter from a purely scientific point of view. The aim of the exhaustive paper contributed by Mr. C. H. Ridsdale was to show the practical value of the microscope to the steel maker and user at the present day. The time has now arrived, he points out, when it should be recognised that composition only indicates such well-defined effects as are generally understood without certain narrow limits of treatment, which are termed "normal." Outside these limits the effect of the treatment far outweighs that of the composition. In the discussion of this paper the President, Mr. Greiner, Mr. Harbord and Mr. Stead took part.

Mr. J. W. Miller contributed a paper on pig iron fractures and their value in foundry practice. He gave instances of the loss sustained by the manufacture of pig iron owing to the present method of grading pig iron by fracture.

The present position of the solution theory of carburised iron was discussed by Dr. A. Stansfield. The conclusions he has arrived at with respect to the atomic complexity in carbon are as follows:—

The carbon in molten iron is in a state of simple solution; the molecule of carbon must then contain one or two atoms, and is probably monatomic. The solidified iron is in the γ state and contains free carbon in solution. The molecular weight of this carbon has not been discussed, but it is probably the same as that in the molten iron. The carbon in solid solution combines with iron, on cooling, to form a carbide, which is probably expressed by the formula $2(Fe_3C)$. When, on further cooling, this carbide falls out of solution as cementite, its formula may become more complicated; the solution theory affords no information on this point; but Sir W. Roberts-Austen stated in his presidential address that the nature of the products of its solution in acids led to the conclusion that the molecule may contain six atoms of carbon, and is at least as complex as would be indicated by the formula $6(Fe_3C)$. There appears to be a belief that the solution theory is in a sense opposed to, and has gone far to supplant, the older allotropic theory; but this paper will, it is hoped, effectually dissipate such an error, as it shows how entirely the solution theory of the relations of carbon and iron involves the allotropic changes with which the distinguished name of Osmond is so inseparably connected.

In the discussion of this paper Mr. Snelus, Mr. Hadfield and Mr. Stead took part.

Mr. A. Sauveur, of Boston, contributed a paper on the changes of structure brought about in steel by thermal and mechanical treatment. He showed that as the smaller the grains of the metal the more ductile and tough it will be, as the finest possible structure results from heating to Brinell's point W, the temperature at which the passage of cement carbon into hardening carbon during the heating of steel takes place, namely, 655° to 730° C., it is evident that every finished piece of unhardened steel should as a last treatment be heated to that temperature.

Prof. E. D. Campbell, of Ann Arbor, Michigan, contributed a paper on the constitution of steel. The general method employed for studying the products of steel was to dissolve the steel in hydrochloric acid, pass the gas evolved through bromine in order to convert unsaturated hydrocarbons of the general formula C_nH_{2n} into their di-brom derivatives $C_nH_{2n}Br_2$; the gas passing through the bromine being measured, and the carbon existing as gaseous paraffins being determined by explosion and absorption of the carbon dioxide produced. The di-brom derivatives, after proper purification, drying, and weighing, were analysed and fractionally distilled for the purpose of qualitatively identifying the various constituents; although the fractional distillation of the di-brom derivatives had shown the presence of ethylene, propylene, butylene, pentylene, and hexylene di-bromides, and dibutylene tetrabromide, later investigations had shown that this last product was the result of the polymerisation under the influence of heat during distillation of butylene di-bromide, and was not present to any considerable extent, at least in the original derivatives. Although the di-brom derivatives from ethylene dibromide ($C_2H_4Br_2$) to hexylene dibromide ($C_6H_{12}Br_2$) had been detected qualitatively, the separation of the various derivatives by fractional distillation *in vacuo* was not sufficiently sharp to give accurate quantitative results in regard to the amount of each constituent present. From the percentage of bromine in the di-brom derivatives the average number of carbon atoms in the molecule was calculated, the results of the examination of a few samples of steel by the above method being shown in the following table:—

Name.	Heat treatment.	Per cent. of carbon of steel.	Per cent. of carbon as derivatives.	Per cent. of carbon as gaseous paraffins.	Per cent. of carbon unaccounted for.	Per cent. of bromine in derivatives.	Calculated carbon atoms in carbon molecule of derivatives.
F	Annealed	0·55	37·1	33·6	29·3	72·56	4·32
F	Hardened and tempered	0·55	25·0	...	...	75·65	3·67
C	Annealed	1·14	43·4	37·9	18·7	73·85	4·05
C	Hardened	1·14	29·0	48·6	22·4	77·61	3·31
D	Annealed	1·28	31·0	44·3	24·7	77·80	3·26
	Pure Carbide from D anneal'd	6·64	35·3	25·2	39·5	...	4·41

The number of carbon atoms in the carbon molecule of the derivatives from the pure carbide, given in the above table, was obtained from the analysis of the gas by dividing the volume of carbon dioxide, produced from the explosion of the olefines, by the volume of the olefines exploded. The hypothesis suggested by the author made the fundamental assumption that carbon formed with iron a series of compounds which might properly be termed "ferrocarbons," on account of their similarity in structure to hydrocarbons. This series of ferrocarbons had the empirical formula $(CFe_3)_n$; or, C_nFe_{3n}, and should be considered as being derived from the hydrocarbons of the olefine series with the general formula C_nH_{2n} by the replacement of the H_2 by the bivalent group Fe_3. These ferrocarbons, dissolved in hydrochloric acid, yield as their primary products of solution the corresponding olefines and hydrogen.

During the meeting excursions were arranged to the locomotive works at Horwich, to the Simon-Carvès coke ovens near Barnsley, to the Manchester Ship Canal, to the ironworks of Platt Brothers, Ltd., at Oldham, to the boiler works of Galloways, Ltd., and to the steel works at Crewe; and hospitality was lavishly dispensed to the members by the Duke of Devonshire at Chatsworth, by the Lord Mayor of Manchester, and by the Mayor of Salford.

MAGNETO-OPTIC ROTATION AND ITS EXPLANATION BY A GYROSTATIC SYSTEM.[1]

II.

I MUST now endeavour to give some slight account of the theories that have been put forward in explanation of magneto-optic rotation. There is an essential distinction between it and what is sometimes called the natural rotation, the plane of polarised light produced by substances, such as solutions of sugar, tartaric acid, quartz, &c., some of which rotate the plane to the right, some to the left. When light is sent once along a column of any of those substances without any magnetic field, its plane of rotation is rotated just as it is in heavy glass or bisulphide of carbon in a magnetic field. But if the ray, after passing through the column of sugar or quartz, is received on a silvered reflector and sent back again through the column to the starting point, its plane of polarisation is found to be in the same direction as at first. Quite the contrary happens when the rotation is due to the action of a magnetic field. Then the rotation is found to be doubled by the forward and backward passage, and it can be increased to any required degree by sending the ray backward and forward through the substance, as shown in this other diagram (Fig. 8).

Thus the rotations in the two cases are essentially different, and must be brought about by different causes. In fact, as was first, I believe, shown by Lord Kelvin, the annulment of the turning in quartz, and the reinforcement of the turning in a magnetic field, produced by sending the ray back again after reflection at the surface of an optically denser medium, points to a peculiarity of structure of the medium as the cause of the turning of the plane of polarisation in sugar solutions and quartz, and to the existence of rotation in the medium as the cause of the turning in a magnetic field. Think of an elastic solid, highly incompressible and endowed with great elasticity of shape and of the same quality in different directions—a stiff jelly may be taken as an example to fix the ideas. Now let one portion of the jelly have bored into it a very large number of extremely small corkscrew-shaped cavities, having their axes all turned in the same direction. Let another portion have imbedded in it a very large number of extremely small rotating bodies, spinning-tops or gyrostats in fact, and let these be uniformly distributed through the substance, and have their axes all turned in the same direction.

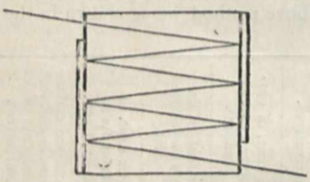

FIG. 8.

Both portions would transmit a plane-polarised wave of transverse vibration travelling in the direction of the axes of the cavities or of the tops with rotation of the plane of polarisation; but in the former case the wave, if reflected and made to travel back, would have the original plane of polarisation restored; in the latter the turning would be doubled by the backward passage.

To understand this it is necessary to enter a little in detail into the analysis of the nature of plane-polarised light. As I have already said, the elastic solid theory may not express the facts of light propagation, but only a certain correspondence with the facts. But its use puts this matter in a very clear way. In a ray of plane polarised light each portion of the ether has a motion of vibration in a line at right angles to the ray, and the direction of this line is the same for each moving particle. The lines of motion and the relative positions of the particles in a wave are shown in the first diagram (Fig. 1 p. 379). As the motion is kept up at the place of excitation, it is propagated out by the elastic resistance of the medium to displacement, and the configuration of particles travels outwards with the speed of light, traversing a wave-length (represented in the diagram by the distance between two particles of the row in the same phase of motion) in the period of complete to-and-fro motion of a particle in its rectilineal path.

Now, a to-and-fro motion such as this can be conceived as made up of two opposite uniform and equal circular motions. Think of two distinct particles moving in the two equal circles A B in this diagram (Fig. 9), with equal uniform speeds in opposite directions. Let each particle be at the top of its circle at the same instant; then at any other instant they will be in similar positions, but one on the right, the other on the left of the vertical diameter of the circle. Thus at that instant each particle is moving downward or upward at the same speed, while with whatever speed one is moving to the left, the other is moving with precisely that speed towards the right. Imagine now these two motions to be united in a single particle. The vertical motions will be added together, the right and left motions will cancel one another, and the particle will have a motion of vibration in the vertical direction of range equal to twice the diameter of the circles, and in the period of the circular motions.

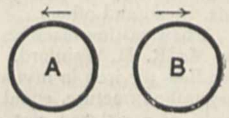

FIG. 9.

The rate of increase of velocity of the particle at each instant is the resultant obtained by properly adding together the accelerations of the particles in the circular motions, and therefore the force which must act on the particle to cause it to describe the vibratory motion just described is the resultant of the forces required to give to the two particles the circular motions which have just been considered.

Now, what we have done for any one particle may be conceived of as done for all the particles in a wave. To understand the nature of a wave in this scheme, we must think of a series of particles originally in a straight line in the direction of propagation of the ray, as displaced to positions on a helix surrounding that direction. Fig. A of this diagram (Fig. 10), regarded from the lower end, and the black spots on the model before you, show a left-handed helical arrangement. Let these particles be projected with equal speeds in the circular paths represented by the circle at the bottom of Fig. A. On this circle are seen

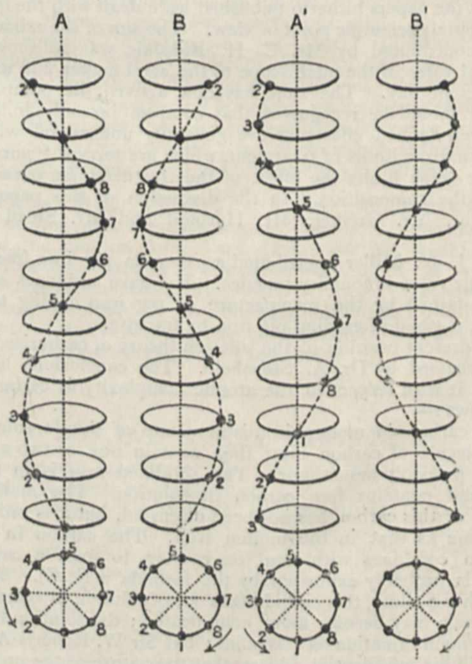

FIG. 10.

the apparent positions of different particles in the helical arrangement when it is viewed by an eye looking upwards along its axis. This motion is shown by that of the black spots on the surface of the model (Fig. 11), when I set it into rotation about its axis. Let the particles be constrained to continue in motion exactly in this manner. As the model shows, the helical arrangement of the particles is displaced along the cylinder. This is the mode of propagation of a *circularly* polarised wave, which is made up of helical arrangements of particles which were formerly in straight lines parallel to the axis.

The direction of propagation of the wave is clearly from the

[1] A discourse delivered at the Royal Institution by Prof. Andrew Gray, F.R.S. (Continued from p. 381.)

bottom of the diagram to the top, and from the end of the model towards your left to the other, when the particles have a right-handed motion, and is in the contrary direction when the direction of rotation is reversed. For a right-handed helical arrangement the direction of propagation for the same direction of motion of the particles is the opposite of that just specified. The direction of propagation remains, therefore, the same when the direction of motion and the helical arrangement of the particles are both reversed. All this can be made out from the diagram. Fig. B shows part of a right-handed arrangement of particles corresponding to the opposite arrangement of Fig. A; and if the particles have the motions shown at the bottom of the diagram the propagation will be for both in the same direction, from the bottom to the top.

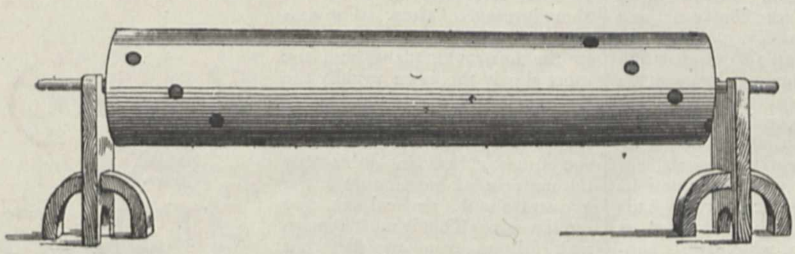

FIG. 11.

In Fig. 10 we suppose the periods equal and also the wave-lengths, the distance along the axis from particle 1 to particle 9. The combination of the circular motions A and B gives rectilinear motion; the combination of the wave motions of Figs. A and B gives a plane polarised wave the plane of polarisation of which does not change in position. If, however, while the periods were equal, the wave-lengths were unequal as shown in this other diagram (Fig. 12), the plane of polarisation would rotate, as shown by the lines drawn across the paths in the figure on the right, for the circular motions of particles in the longer wave would gain on those in the shorter.

A little consideration will show that the direction of the resultant rectilinear motion will, in consequence of the unequal speeds of propagation, turn round as the wave advances, and will do so in the direction of motion of the particles in the more quickly travelling wave, generating the screw surface shown in the model I have already exhibited.

We must now consider the forces. The particles moving in the circular paths have accelerations towards the centres of these paths, and forces must be applied to them to produce these accelerations. These forces are applied in the present theory by the action of the medium, and it is the reactions of the particles on the medium that are properly called the centrifugal forces of the particles. The requisite centreward forces then are supplied by the state of strain into which the medium is thrown by the displacement of parts of it, which form in the undisturbed position a series of straight arrays in the direction of propagation, into these helical arrangements round that direction. The greater these elastic forces the greater the velocity of propagation of the wave.

In an elastic medium these forces depend on the *amount* of the relative displacements of the particles, and will be greater for displacements in the right-hand helical arrangement than for displacements in the opposite direction if the medium has a greater rigidity for right-handed distortion than for left, and the right-handed wave of distortion will be transmitted with greater speed, and *vice versâ*. This is the case of solutions of sugar and tartaric acid, quartz, &c., for which a helical structure has been supposed to exist in the medium.

Taking this case refer to Figs. A and B of our large diagram (Fig. 10), and let the right-handed wave travel the faster. Let the waves travel up, be reflected at the upper ends, as at the surface of a denser medium, and then travel down again. The reflected waves are those shown in Figs. A′, B′ of the diagram. By the reflection, the helical arrangement will be unaltered. But the plane of polarisation, as we have seen, turns round in space in the direction of the motion of the particles in the more quickly moving wave; it therefore turns round in the direction of the hands of a watch as the wave moves in the upward direction in the diagram, and in the opposite direction when the wave is travelling back. Thus the rotation of the plane of polarisation produced in the forward passage is undone in the backward.

It is easy to see that the same thing will take place if the reflection is at the surface of an optically rarer medium, so that the direction of motion of the particles is the same in the reflected as in the direct wave. The helical arrangements, however, are reversed by the reflection, and hence the wave which travelled the more quickly forward travels the more slowly back, and again the turning of the plane of polarisation is annulled by the backward passage. Thus Lord Kelvin's hypothesis of difference of structure completely explains the phenomena.

We pass now to the other case, that of magneto-optic rotation. Let us suppose, to fix the ideas, that the right-handed circular ray travels faster than the other, and that whether direct or reversed. Here, as in the other case, the elastic reaction of the medium on the displaced particles depends only on the distortion, and if there be no structural peculiarity in the medium there must be the same reaction in the particles in both the circular waves which combine to make up the plane-polarised one.

Thus the actions on the particles being the same for both waves, and the velocities of propagation being different, the motions concerned in the light propagation cannot be the same. There must in fact be a motion already existing in the medium which, compounded with the motions concerned in light propagation, give two motions which give equal reactions in the medium against the equal elastic forces, applied to the particles in the case of equal helical displacements.

Thus Lord Kelvin supposes that in the medium in the magnetic field there exists a motion capable of being compounded with the luminiferous motion of either circularly polarised beam. The latter is thus only a component of the whole motion.

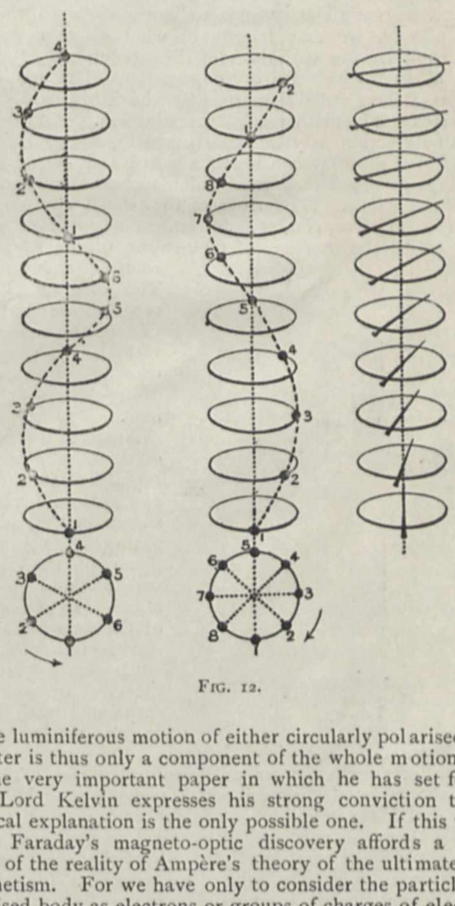

FIG. 12.

In the very important paper in which he has set forth his theory Lord Kelvin expresses his strong conviction that his dynamical explanation is the only possible one. If this view be correct, Faraday's magneto-optic discovery affords a demonstration of the reality of Ampère's theory of the ultimate nature of magnetism. For we have only to consider the particles of a magnetised body as electrons or groups of charges of electricity, ultimate as to smallness, rotating about axes on the whole in alignment along the direction of the magnetic force, and with a preponderance of one of the two directions of rotation over the other. Each rotating molecule is an infinitesimal electromagnet, of which the current distribution is furnished by the system of convection currents constituted by the moving charges.

The subject of magneto-optic rotation has also been considered by Larmor, and two types of theory of these effects have been indicated by him in his report on the "Action of Magnetism on Light." One is represented by Lord Kelvin's theory, which is illustrated by Maxwell's chapter on molecular vortices in his "Electricity and Magnetism." FitzGerald's paper "On the Electromagnetic Theory of the Reflection and Refraction of Light," in the *Philosophical Transactions* for 1880, is related to Maxwell's theory, and explains the rotation produced by reflection from the pole of a magnet by means of the addition of a term to the energy of the system. The other theory is also a purely electromagnetic one, and supposes that the effects are due to a kind of æolotropy of the medium set up by the magnetisation, and so attributes them to a change of structure which introduces rotational terms into the equations connecting *electric* displacements and electric forces. This latter theory therefore regards the magneto-optic rotation as only a secondary effect of the magnetisation, which is not supposed to exert any direct dynamical influence on the transmission of the light-waves.

It is not possible here to enter into the subject of these theories, but I should like to direct attention to a paper by Mr. J. G. Leathem, published in the *Philosophical Transactions*, in which the type of theory just referred to has been worked out and compared in its results with the experiments of Sissingh and Zeeman in reflection. These investigators made measurements of the phase and amplitude of the magneto-optic component of the reflected light for various angles of incidence. For both these quantities the theoretical results of Leathem agree very well with the observed values.

Returning now to the gyrostatic medium, between which and the electromagnetic theory, it is to be remembered, there is a correspondence, we may inquire in what way the gyrostats, when moved by the vibrations of the medium, react upon it, and so affect the velocity of propagation. The motion of a gyrostat is often regarded as mysterious, and it can hardly be fully explained except by mathematical investigation. But the general nature of its action may be made out without much difficulty. First of all, a gyrostat consists of a massive fly-wheel running on bearings attached to a case which more or less completely encloses the wheel. The mass of the wheel consists in the main of a massive rim, which renders as great as possible what is called the moment of momentum of the wheel when rotating about its axis. The diagram (Fig. 13) represents a partial section of the case and fly-wheel of a gyrostat, showing the arrangement of fly-wheels and bearings.

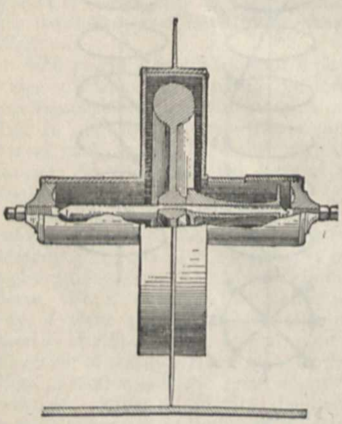

FIG. 13.

Now let the fly-wheel of such a gyrostat be rapidly rotated, and the gyrostat be hung up as shown in this other diagram (Fig. 14), with the plane of the fly-wheel vertical, and a weight attached to one extremity of the axis. The gyrostat is not tilted over, but begins to turn round the cord by which it is suspended with a slow angular motion which is in the direction of the horizontal arrow, if the direction of rotation is that of the circular arrow shown on the case. The same thing is shown by the experiment I now make. I spin this gyrostat and hang it with the axis of rotation horizontal by passing a loop of cord round one end of the axis so that the weight of the gyrostat itself forms the weight tending to tilt it over about the point of suspension. The axis of rotation here again remains nearly horizontal, but turns slowly round in a horizontal plane as before.

The explanation in general terms is this. The weight gives a couple tending to turn the gyrostat about a horizontal axis at right angles to that of rotation. This couple in any short interval of time produces moment of momentum about the axis specified, the amount of which is the moment of the couple multiplied by the time, and may be represented in direction and magnitude by the line OB. This must be compounded with the moment of momentum OA already existing about the axis of rotation, and gives for the resultant moment of momentum the line OC, which is the direction of the axis of rotation after the lapse of the short interval of time. The axis of rotation thus turns slowly round in the horizontal plane, and the more slowly the more rapidly the fly-wheel rotates.

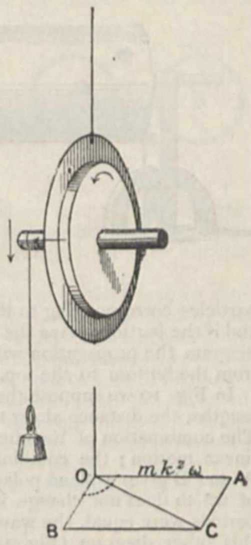

FIG. 14

The gyrostat in fact must have this precessional motion, as it is sometimes called, in order that the moment of momentum of the gyrostat about a vertical axis may remain zero. That it must remain zero follows from the fact that there is no couple in a horizontal plane acting on the gyrostat.

Thus any couple tending to change the direction of the axis in any plane produces a turning in a perpendicular plane. For example, if a horizontal couple, that is about a vertical axis, were applied to the axis of the gyrostat in the last figure it would turn about a horizontal axis, that is, would tilt over.

Again, consider a massive fly-wheel mounted on board ship on a horizontal axis in the direction across the ship. The rolling of the ship changes the direction of the axis, and produces a couple applied by the fly-wheel to the bearings and an equal and opposite couple applied by the bearings to the fly-wheel. This couple is in the plane of the deck, and is reversed with the direction of rolling, and has its greatest value when the rate of turning of the ship is greatest. Thus the force on one bearing is towards the bow of the ship, the force on the other towards the stern, during a roll from one side to the other; and these forces are reversed during the roll back again. This is the gyrostatic couple exerted on its bearings by the armature of a dynamo on shipboard.

In the same way, when a gyrostat is embedded in a medium and the medium is moving so as to change the direction of the axis of rotation, a couple acting on the medium in a plane at right angles to the plane of the direction of motion is brought into play. To fix the ideas, think of a row of small embedded gyrostats along this table with their axes in the direction of the row, and their fly-wheels all rotating in the same direction. Now let a wave of transverse displacement of the medium in the vertical direction pass along the medium in the direction of the chain. The vibratory motion of each part of the medium will turn the gyrostatic axis from the horizontal, and thereby introduce horizontal reactions on the medium. Again, a wave of horizontal vibratory motion will introduce vertical reactions in the medium from the gyrostats.

Now, a wave of circular vibrations, like those we have already considered, passing through the medium in the direction of the chain, could be resolved into two waves of rectilinear vibration, one in which the vibration is horizontal, and another in which the vibration is vertical, giving respectively vertical and horizontal reactions in the medium. The magnetisation of the medium is regarded as due to the distribution throughout it of a multitude of rotating molecules, so small that the medium, notwithstanding their presence, seems of uniform quality. The molecules have, on the whole, an alignment of their axes in the direction of magnetisation. These reactions on the medium when worked out give terms in the equations of wave propagation of the proper kind to represent magneto-optic rotation.

It is worthy of mention that the addition of such terms to the equation was made by McCullagh, the well-known Irish mathematician, who, however, was unable to account for them by any physical theory. The necessary physical theory may be regarded as afforded by the mechanism which thus forms an essential part of Lord Kelvin's mode of accounting for magneto-optic effects.

Lord Kelvin, in his Baltimore Lectures, has suggested for magneto-optic rotation a form of gyrostatic molecule consisting, as shown in the figure, of a spherical sheath enclosing two equal gyrostats. These are connected with each other and with the case by ball-and-socket joints at the extremities of their axes, as shown in Fig. 15. If the spherical case were turned round any axis through the centre no disalignment of the gyrostats contained in it would take place, and it would act just like a simple gyrostat. If, however, the case were to undergo translation in any direction except along the axis, the gyrostats would lag behind, and the two-link chain which they form would bend at the centre. This bending would be resisted by the quasi-rigidity of the chain produced by the rotation, and the gyrostats would react on the sheath at the joints with forces as before at right angles to the plane in which the change of direction of the axis takes place.

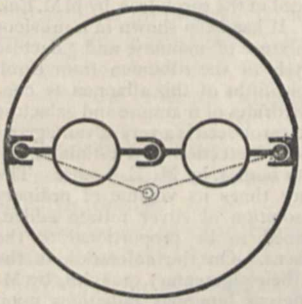

FIG. 15.

The general result is, that if the centre of this molecule be carried with uniform velocity in a circle in a plane at right angles to the line of axes, the force required for the acceleration towards the centre, and which is applied to it by the medium, is greater or less according as the direction in which the molecule is carried round is with or against the direction of rotation of the gyrostats. That is, the effect of the rotation is to virtually increase the inertia of the molecule in the one case and diminish it in the other.

These molecules embedded in the medium are supposed to be exceedingly small, and to be so distributed that the medium may, in the consideration of light propagation, be regarded as of uniform quality. Lord Kelvin's last form of molecule, it may be pointed out, if the surface of its sheath adheres to the medium, will have efficiency as an ordinary single gyrostat as regards rotations of the molecule, and efficiency likewise as regards translational motion of the centre of the molecule. The former efficiency can be made as small as may be desired by making the molecule sufficiently small; the latter may be maintained at the same value under certain conditions, however small the molecule be made.

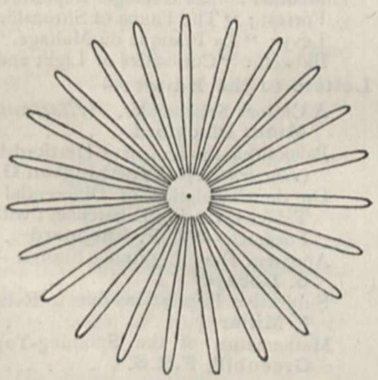

FIG. 16.—Path of the Bob of a Gyrostatic Pendulum. As the pendulum moves, it passes from one ray to another on the opposite side, and the direction of motion at each swing alters through the angle between two rays. The central parts of the rays are left out. The marking point does not pass exactly through the centre.

The lately discovered effect of a magnetic field in giving one period of circular oscillation of a particle or another according as the particle is revolving in one direction or the other about the direction of the magnetic force, is connected with magneto-optic rotation. There is a connection between velocity of propagation and frequency of vibration, which is exemplified by the phenomena of dispersion. In the Faraday effect, the two modes of vibration, if of the same period, have different velocities of vibration, consequently these two modes of vibration must have different frequencies for the same velocity of propagation.

The vibrations of the molecules of a gas in which the Zeeman effect is produced by a magnetic field may be represented by the motion of a pendulum the bob of which contains a rapidly rotating gyrostat with its axis in the direction of the supporting wire of the pendulum. The period of revolution of the bob when moving as a conical pendulum is greater or less than the period when the gyrostat is not spinning according as the direction of revolution is against or with the direction of rotation.

The bob when deflected and let go moves in a path which constantly changes its direction, so that if a point attached to the bob writes the path on a piece of paper, a star-shaped figure is obtained. I cause the gyrostatic pendulum here suspended to draw its path by a stream of white sand on the black board placed below it, and you see the result.

I must here leave the subject, and may venture to express the hope that on some other occasion some one more specially acquainted with the electromagnetic aspects of the phenomenon may be induced to place the latest results of that theory before you.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MR. JAMES BROWN THOMSON, of Kinning Park, Glasgow, who died ten months ago, left 80,000*l.* to Glasgow institutions—mostly educational and benevolent. The Glasgow University will receive 10,000*l.*

THE recent discussion in NATURE on "The Duties of Provincial Professors" forms the subject of a short critique in the August number of the *Educational Review.* While fully endorsing the general views expressed in our columns, the *Review* remarks: "There is only one flaw in the indictment—the insinuation, namely, that university professors should take no part in the social life and physical activities, the general discipline, the corporate existence of the university or university college." But where does this flaw exist? No such insinuation is made in the article in NATURE.

THE Department of Science and Art has issued the following list of successful candidates for Royal Exhibitions, National Scholarships, and Free Studentships (Science) awarded this year:—Royal Exhibitions: William M. Selvey, Edward C. Moyle, Archibald D. Alexander, Charles W. Price, George F. A. Cowley, Edgar Sutcliffe, Sydney A. Edmonds. National Scholarships for Mechanics: Francis P. Johns, George F. Turner, Walter A. Scoble, Arthur J. Spencer, William H. Adams. Free Studentships for Mechanics: R. Borlase Matthews, William H. Outfin. National Scholarships for Physics: William R. Daniel, William J. Lyons, James Lord, William M. Varley, Wilfred H. Clarke. Free Studentships for Physics: John H. Shaxby, Gerald Henniker. National Scholarships for Chemistry: William D. Rogers, John H. Crabtree, Howard E. Goodson, Arthur H. Higgins, Montague W. Stevens. Free Studentships for Chemistry: John R. Horsley, Arthur C. Nicholson. National Scholarships for Biology: Eric Drabble, Louis E. Robinson, Ernest A. Wraight, Reginald F. G. Bayley, Harold B. Fantham. National Scholarships for Geology: William H. Goodchild, Thomas Thornton.

THE following list of candidates, successful in this year's competition for the Whitworth Scholarships and Exhibitions, has been received from the Department of Science and Art:—Scholarships, tenable for three years, 125*l.* a year each: Alec W. Quennell, London; Hanson Topham, Great Horton, Bradford; William V. Shearer, Langside, Glasgow; George Wall, Oldham. Exhibitions, tenable for one year, value 50*l.* each: Arthur J. Spencer, Portsmouth; George F. Turner, Sheffield; Harold P. Philpot, London; William H. Adams, Devonport; Edward C. Moyle, Devonport; Walter A. Scoble, E. Stonehouse, Devon; Archibald D. Alexander, Portsmouth; Sydney A. Edmonds, Devonport; George F. A. Cowley, Portsmouth; Albert Wilson, Leeds; Edwin J. Britton, Portsmouth; Harry Duncan, Plumstead; Samuel C. Rhodes, Morley, Leeds; Harry M. Andrew, Manchester; Alexander P. Traill, North Shields; Leonard Bairstow, Halifax; William T. S. Butlin, Bristol; Albert E. Dodridge, Devonport; James Lowe, Alloa; William J. Rodd, Plumstead; Francis C. Rendle, Plymouth; Thomas E. Heywood, Cardiff; James Paul, Woolwich; Charles P. Raitt, Portsmouth; Charles H. Booth, Bolton; Edward Howarth, Oldham; Percy Down, London; Marshall H. Straw, Sneinton, Nottingham; R. Borlase Matthews, Swansea; Samuel Crossley, Oldham.

SOCIETIES AND ACADEMIES.

EDINBURGH.

Royal Society, July 17.—The Hon. John Abercromby in the chair.—The Keith prize for the period 1895–97 was awarded to Dr. Thomas Muir, for his valuable mathematical papers published in the *Transactions* and *Proceedings*. The Makdougall-Brisbane prize for the period 1896–98 was awarded to Dr. William Peddie, for his experimental researches on the torsion of wires, his discussion of a unique case of colour-blindness, and other investigations in physical science. The Neill prize for 1895–98 was awarded to Prof. Cossar Ewart, for his important investigations bearing on the theory of heredity.—A paper by Lord Kelvin, on magnetism and molecular rotation, was communicated, the main conclusion of which was that a gyrostatic molecule could not in a strong magnetic field give the Zeeman effect. Only a broadening of the lines, not a splitting, could occur. This agreed with Larmor's statement; and the probability was that Lorentz's theory was essentially true.—Sir John Murray and Mr. F. P. Pullar read a first instalment of their account of a bathymetrical survey of the Scottish fresh-water lochs. These could be divided into two great classes, the deep and the shallow. The shallow lochs varied considerably in temperature throughout the year—a fact which had an important bearing on the forms of animal life frequenting these lochs. The lochs discussed were Lochs Katrine, Arklet, Achray, Vennacher, Drunkie, Voil, Doine, and Lubnaig. 2422 soundings had been taken. The greatest depth observed in Loch Katrine was 495 feet; and about one square mile of the bottom of this loch was below sea level. The portable sounding machine used had been designed by Mr. Pullar.—Dr. Hepburn exhibited a new osteometric board, the idea of which was to keep the vertical sliding piece always perfectly parallel to itself. This was effected by means of two brass rods parallel to each other and parallel to the graduated board. These passed through holes in the vertical sliding piece. By this simple device all irregularities in successive measurements of the same bone were quite done away with.

PARIS.

Academy of Sciences, August 14.—M. Maurice Lévy in the chair.—Researches on the metallic derivatives of acetylene, by MM. Berthelot and Delépine. Thermochemical experiments on the compounds of acetylene with silver, silver nitrate, silver sulphate, silver chloride and iodide. Dry silver acetylide, Ag_2C_2, detonates when heated in a vacuum with production of a reddish flame. The authors discuss the nature of this explosion, since the products being solids, silver and carbon, no flame would be expected. The conclusion is arrived at that the temperature of the reaction is sufficient to volatilise the carbon, and that the flame is gaseous carbon at a very high temperature approaching 4000° C.—Reaction of argon and nitrogen with mercury alkyls, by M. Berthelot. Mercury methyl, $Hg(CH_3)_2$, submitted in an atmosphere of argon to the action of the silent electric discharge, forms no compound with argon, although when the argon is replaced by nitrogen the latter is readily absorbed. With mercury phenyl, $Hg(C_6H_5)_2$, a slight absorption of argon is noticeable, amounting to about 5 per cent. in twenty-three hours.—Observations of Tempel's Comet (1873 II.), made at the Observatory of Paris (with the 30·5 centimetre equatorial), by M. G. Fayet. The observations were carried out on the nights of July 31, August 9 and 10. The comet was at its brightest on July 31, although very low down on the horizon.—Observations of the Perseids of 1899, by Mlle. D. Klumpke. These observations were made under very favourable conditions of sky between August 9 and 13.—On the shower of shooting stars (Perseids) at Lyons, and a remarkable meteor, by M. Ch. André. The August showers of shooting stars were relatively small in number at Lyons. On the evening of the 11th a remarkable meteor was seen starting at about 10·43 p.m. from the constellation of Hercules. It was bluish-white at first, changing abruptly in colour to an orange-red. It was under observation for four seconds.—On the correspondence between right lines and spheres, by M. O. E. Lovett.—On the black pottery earths, by M. H. Le Chatelier. The property of producing black ware by the action of air charged with tar vapour at a high temperature is found to be intimately related with the presence of iron in the earth; in the absence of iron, a greyish coloration at the most is produced in the interior, nearly all the carbon remaining in the outside crust. The most satisfactory results were obtained by acting with acetylene for a quarter of an hour at 450° to 480° upon an earth containing about 2 per cent. of iron oxide. The objects are then removed to a furnace and baked at about 1200°, the hardness thus obtained being comparable with that of porcelain.—On Egyptian porcelain, by M. H. Le Chatelier.—Action of sodammonium and potassammonium upon tellurium and sulphur, by M. C. Hugot. With the alkali in excess the products were Na_2S, K_2S, Na_2Te, K_2Te, all white amorphous substances, soluble in water, but insoluble in liquid ammonia, and incapable of absorbing ammonia. With the sulphur or tellurium in excess, the products are Na_2S_5, K_2S_5, Na_2Te_3, K_2Te_3, all crystalline, soluble in water and in liquid ammonia, and capable of absorbing ammonia gas.—On the composition of the albumen of the seed of the carob tree, by MM. Em. Bourquelot and H. Hérissey. It has been shown in a previous paper by the authors that a mixture of mannose and galactose results from the careful hydrolysis of the albumen from carob seeds. It is now found that four-fifths of this albumen is constituted by a mixture of the anhydrides of mannose and galactose (mannane and galactane). The carob seed is a very advantageous source of crystallised mannose.—Detection and estimation of free phosphorus in oils and fatty bodies, by M. E. Louise. The oil or fat is dissolved in twenty times its volume of ordinary acetone, and a concentrated solution of silver nitrate added. The silver produced is assumed to be proportional to the amount of free phosphorus present.—On the coloration of the Tunicates and the mobility of their pigmentary granules, by M. Antoine Pizon.—Action of different luminous radiations upon silkworms in different stages, by M. C. Flammarion.

CONTENTS.