THURSDAY, JANUARY 18, 1894.

HEINRICH HERTZ.

THE last day of 1893 witnessed the tragic death of Prof. Milnes Marshall on Scawfell: on the New Year's Day Prof. Heinrich R. Hertz passed away, and his death will be even more severely felt in many circles and more widely mourned. For some time he had not been in good health. Last winter a severe illness prevented him from discharging his professional duties: for some weeks he was confined to his bed, and fears were entertained that he might not recover. During the summer-semester he got better and was again able to lecture; a casual observer would scarcely have thought that there was anything wrong with him. He was in excellent spirits, and his friends hoped that the vacation would complete his restoration to health and strength. But with the returning winter there came a relapse. A chronic, and painful, disease of the nose spread to the neighbouring Highmore's cavity and gradually led to blood-poisoning. He was conscious to the last, and must have been aware that recovery was hopeless; but he bore his sufferings with the greatest patience and fortitude.

Hertz is best known through his magnificent series of researches on electric waves. He was led, somewhat indirectly, to these by a problem proposed in 1879 by the Berlin Academy of Sciences, viz. to establish experimentally a relation between electromagnetic forces and the dielectric polarisation of insulators. At this time Hertz was assistant in the Berlin Physical Institute, and his attention was directed to the problem by Prof. von Helmholtz. The oscillations of Leyden jars and of open induction-coils first attracted his attention; but he reluctantly came to the conclusion that any decided effect could scarcely be hoped for. Yet he kept the matter in mind; and certain experiments made a few years later—when he had become Professor of Physics at the Karlsruhe Polytechnic—led him to the production and examination of electric oscillations of very short period (about a hundred-millionth of a second). The paper "On very Rapid Electric Oscillations," which was published in 1887, was the first of a splendid series of researches which appeared in *Wiedemann's Annalen* between the years 1887 and 1890, and in which he showed, with ample experimental proof and illustration, that electromagnetic actions are propagated with finite velocity through space. These twelve epoch-making papers were afterwards republished—with an introductory chapter of singular interest and value, and a reprint of some observations on electric discharges made by von Bezold in 1870—under the title *Untersuchungen über die Ausbreitung der elektrischen Kraft*. (An English translation of this book, with a preface by Lord Kelvin, has just been published.)

As early as 1883, Prof. G. F. Fitzgerald read a paper at the Southport meeting of the British Association, "On the Energy Lost by Radiation from Alternating Currents," and at the same meeting pointed out that electromagnetic waves of as little as two metres wave-length, or even less, could be obtained by discharging an accumulator through a small resistance. In a paper on "The Theory of Lightning-Conductors," published in the *Phil. Mag.* in August, 1888, Dr. O. J. Lodge suggested that waves of 20 or 30 c.m. length from a small condenser might be concentrated upon some sensitive detector; that shorter waves still might be obtained by discarding the condenser and simply producing oscillations in a sphere or cylinder by giving it a succession of sparks; and that light-waves in all probability were only smaller editions of these. It was reserved for Hertz to discover, and apply with marvellous ingenuity, the necessary "detector," a resonating circuit with an air-gap, the resistance of which is broken down by well-timed impulses so that visible sparks are produced. It was only after this paper was written that Dr. Lodge read how Hertz had succeeded in detecting electromagnetic waves in free space, in investigating their reflection, and measuring their velocity; and at the end of a postcript to the same paper announcing the news there occurs the sentence: "The whole subject of electrical radiation seems working itself out splendidly." How amply this statement has been substantiated we now know.[1]

When his earlier papers on electric oscillations were written, Hertz was not aware of von Bezold's observations, nor that the subject was engaging the attention of physicists in Great Britain. He readily and gracefully acknowledged the value of the work done by others; and it is equally pleasant to recollect that, when he had attained the goal towards which others were striving, Profs. Oliver Lodge and Fitzgerald were foremost in announcing his success and in preparing the English-speaking world to appreciate the importance of the discoveries which he had made and might yet be expected to make. None, we may be sure, more deeply mourn the death of this brilliant investigator—in his thirty-seventh year—than those who have travelled along the same path, and can fully appreciate the value of his work.

It would perhaps be an exaggeration to say that the news of Hertz's discoveries (with his consequent appointment as successor to Clausius in the chair of Physics at Bonn) reached Germany by way of England. But at the time when these researches were undertaken Maxwell's theory does not appear to have been very widely known in Germany, and it is certain that its importance was not generally recognised. It seems that Hertz himself did not at first appreciate how rich and suggestive it was. But when he showed how worthily he could follow in the footsteps of Faraday and Maxwell, his work received instant and ample recognition in England. In December, 1890, he came over to England to receive the Rumford medal, which was conferred upon him by the Royal Society for his researches on electromagnetic radiation. He was delighted with the warm welcome which he received, and often spoke of it with obvious pleasure.

It might be thought that a world-wide reputation so rapidly attained would produce in a young man some feeling of elation and pride, and in his colleagues somewhat of envy. But Hertz's modesty was proof against the one, and his unvarying courtesy and ready recognition of the merits of his co-workers made the other well-nigh impossible. He was a most lovable man, and was never happier than in giving pleasure to others. He was always ready to show hospitality to scientific men from England and America who came to Bonn. Even under the restraint of a foreign tongue (he spoke and wrote English with considerable fluency) his conversation was charming. When entertaining friends he kept the learned professor well in the background, and his one desire was to make every guest feel at ease and happy. Many of his students will remember with pleasure certain trips to the Siebengeberge, and delightful evenings spent in his house in the Quantius-Strasse.

Absolutely devoid of any desire to pose before the public, Hertz yet showed on occasion that he could ably act as a popular exponent of experimental research. After the publication of his fascinating researches on electric radiation—its rectilinear propagation, reflection, refraction, and polarisation—he was invited to address the *Naturforscherversammlung* (which corresponds to our British Association) at Heidelberg, in 1889. He

[1] It may not be out of place to observe here that Hertz appears to have made a mistake in saying that Poincaré first pointed out the error of calculation in his important paper "On the Finite Velocity of Propagation of Electromagnetic Actions." (English edition, pp. 9, 15, 270.) It seems clear that Lodge (*Phil. Mag.* July, 1889) first drew attention to it.

chose as his subject "The Relations between Light and Electricity." The lecture, afterwards published by Strauss, of Bonn, attracted great attention in Germany, and rapidly passed through half a dozen editions; it deserves to be better known in England. To students of science it will be a pleasure—not unmixed with sadness—to know that shortly before his untimely death he completed the manuscript of a new work on "The Principles of Mechanics." This book is already being prepared for publication, and those who have learned to value the insight and originality of the gifted author will eagerly watch for its appearance. D. E. J.

PROF. DR. RUDOLF WOLF.

IN Prof. Dr. Rudolf Wolf astronomical science loses one of her most devoted servants, and his death will be deplored not only by his countrymen and the observatory which he has directed since its foundation, but by astronomers all over the civilised world.

The services which he has rendered to astronomical science have not been restricted to one branch, although his name is generally spoken of with reference to sunspots.

Born on July 7, 1816, at Fällanden, near Zurich, he attended in his youth the higher schools in the last-mentioned city, where he made the acquaintance of the astronomer Horner, and began his first studies in mathematics and astronomy. He then went to the Vienna University in order to study astronomy under Littrow, and later to Berlin, at which place and time were Encke and Poggendorf. The year 1838 saw him in his home again, and this time his opportunities for astronomical studies were few and far between, as he had little time to spare, owing to his having accepted the post of a teacher in mathematics and physics at the town "Realschule" in Berne. In the year 1844 he commenced lecturing at the university, and in 1852 he obtained his Doctor's degree from the Berne Faculty, the same year becoming a member of that body itself by being appointed an Ausserordentliche Professor. About this time Wolf busied himself with a series of fine pieces of mathematical work, some of which were published singly, and others in various "Fachblättern," and in this year (1852) he published his "Taschenbuch der Mathematik, Physik, Geodäsie und Astronomie," a book which, owing to its clearness of exposition, passed quickly through a series of editions. One of the last pieces of work at which he was employed before he was overtaken by his illness was the sixth edition of this small book. The year 1847 was a very important one in the life of Prof. Rudolf Wolf, for it was at this period that he was appointed to the directorship of the small observatory of Berne. It was there that he began his well-known series of observations on sunspots, which he carried on without intermission to the end of his life, and which in connection with previous observations led to such important results. Owing to his memorable discovery of the relation between sunspots and earth magnetism his name first became better known, and it was more especially on this account that he received his promotion and a professorship of mathematics at the Berne University. In the year 1855 we find him returning as Professor of Astronomy to the newly-founded Swiss Polytechnikum, and at the same time to the university in his "Vaterstadt," where at a later date (1864) he received the appointment as director of the newly-built observatory in which he worked with great zeal to the end of his life.

The chief work which Prof. Wolf set himself to do was to obtain a continuous record of the spots on the solar surface; this led him later to examine older observations, and finally to compare their periods with those obtained from magnetic observations. As an astronomical observer Prof. Wolf was most diligent. Besides busying himself with observations of many different kinds, he made a point of regularly watching the sun's surface. For fifty years, it is said, he did not allow a single day, in which the sun was at all visible, to pass without observing its surface with one of the observatory instruments, or with a small pocket telescope he carried about with him for that purpose. The importance of Prof. Wolf's work will be gathered from the following brief historical sketch.

In 1851 Lamont, the Scotch director of the Munich Observatory, in reviewing the magnetic observations made at Göttingen and Munich from 1835-50, perceived that they gave indications of a period of 10⅓ years. Sabine, in the following winter, ignorant of Lamont's conclusion, undertook a similar examination with very different data, and found that there was a maximum of violence and frequency about every 10 years; he it was, also, who first noted the coincidence between this result and Schwabe's sunspot period. The memoir containing this remarkable communication was presented to the Royal Society March 18, and read May 6, 1852; but on the 31st July following, Prof. Rudolf Wolf at Berne, and on the 18th August, Alfred Gautier at Sion, both announced similar conclusions, arrived at quite separately and independently. Prof. Wolf's work began then in real earnest, and he corrected Schwabe's decennial period to one a little larger than eleven (11·11), and pointed out the better agreement in the ebb and flow of magnetic change than Lamont's 10⅓ year cycles. So minute and exact were his inquiries that by 1859 he found that very considerable fluctuations on either side of the mean period, which he had previously deduced, were noticeable; for might not two maxima rise to sixteen and a half years, or sink below seven and a half years? Prof. Wolf pointed out later (1861) that the shortest periods brought the most acute crises, and *vice versâ*; he it was, also, who suggested the idea of a longer sunspot period (55½ years).

Among other branches of astronomy to which Prof. Wolf turned his attention may be mentioned that of variable stars. It was in 1852 that he pointed out the striking resemblance between sunspot curves (representing frequency) and curves representing the changing luminous intensity of many variable stars. Auroræ, too, received Prof. Wolf's attention, and it was in the same year that, as he was examining Vogel's collection of Zürich chronicles for evidence to connect the weather with sunspots, he was led to associate luminous manifestations with solar disturbances. He also interested himself with regard to the announcement of the discovery of Vulcan, and collected all information of recorded appearances (?) of what were thought to be intra-Mercurian planets.

From his youth up, Prof. Wolf had a great liking for historical study, and was as familiar with the history of his science as he was with the special branch which he made his own. For several years he collected and brought together a great amount of "quellenmaterial," which was published in the form of his "Geschichte der Astronomie." Perhaps his "Handbuch der Astronomie" may be said to be his best work, for there his thorough knowledge of his science and his cleverness had complete scope. The matter in this book is treated with both scientific accuracy and literary ability, and is a wonderful instance of his still youthful capacity for work.

Towards the end of November last the first sign of illness showed itself, and during the first few days of December quickly developed, resulting in his death on December 6, at the age of 77.

Wholly devoted to the science which he loved, and a large contributor to astronomical knowledge, his name will be handed down to posterity. When the principles played with to-day are thoroughly perfected at some future date, and we can produce perfect pictures of all solar phenomena on a single plate, our future astronomers will still look back on the work accomplished by Prof. Rudolf Wolf as a germ from which their work had developed, and as a monument of pains and industry. In his death, besides a true friend, we lose a thorough devotee to science, and we can ourselves mourn with his friends who say, "Und heute stehen seine Freunde aus allen Gauen des Vaterlandes trauernd am offenen Grabe, der Erde die sterbliche Hülle eines Mannes übergebend dessen geistige Grösse, persönliche Bescheidenheit und herzlichste, oft aufopfernde Liebenswürdigkeit allen die ihn gekannt haben unvergeszlich bleiben wird." W. J. L.

CLOUD PHOTOGRAPHY.

LA NATURE recently printed an article by M. A. Angot on the methods he has been employing in order to obtain the excellent photographs of clouds exhibited at the Paris Physical Society at the beginning of last year. The following is a free translation of the article:—

It is well known that ordinary photographic plates are most sensitive to blue and violet rays; hence the blue background of the sky acts, in general, nearly as much upon the plates as the white parts of clouds, which are thus rendered almost or entirely indistinguishable upon the photograph. It is possible, however, easily to obtain views of an interesting effect when, on a background of blue sky, large clouds pass before the sun. The edges of the clouds are then lit up to such an extent that they make much stronger impressions upon the sensitive plate than the sky itself; the remainder of the cloud is, on the contrary, dark, grey or black, and does not come out as well as the sky. To obtain an accurate picture under these conditions it is necessary to develop with great care: or better, to use a dilute pyro developer—a few drops of bromide of potassium solution and very little pyro to begin with; the development is then slowly carried on with the addition of carbonate of soda, and pyro is only added again towards the end if the plate lacks clearness.

This method ceases to give good results when it is applied to ordinary clouds, and becomes altogether useless for cirrus clouds. But these are precisely the clouds the study of which is most interesting; they are composed not of water vapour, but of ice-needles; and their forms and movements are closely connected with changes of weather. Cirri are the most difficult to photograph because, being farther from us than other kinds, they are less brilliant; and further, when they are seen, the sky is very frequently pale blue in colour, or covered with a milky veil, which diminishes the contrast.

Numerous plans have been proposed to photograph cirrus clouds. The first consists in photographing from the summits of high mountains, but that method is not within the reach of everybody. At such places the sky is, in general, much darker, and the clouds are better seen upon the background, so that excellent photographic images can be obtained without special devices. Another method has been proposed by Prof. Riggenbach, and appears to have some advantages. It consists in photographing the sky, using a diaphragm so small and giving an exposure so short that only a trace of the cloud-image appears after development. The plate is then intensified, and the image brought out by means of bichloride of mercury and sodium sulpho-antimoniate. This method, however, has little to commend it. In the first place, intensification is always inconvenient and destroys details, and further, the sodium salt very rapidly deteriorates, so there is always a risk of the plates being spoiled by becoming a very intense yellow colour, or being covered with a metallic deposit.

Prof. Riggenbach has suggested another and a better method, which is found to give excellent results. The method is based upon the fact that the blue light of the sky is partially polarised, whilst the light of clouds does not possess the same property. If, therefore, a convenient analyser (a Nicol's prism or black glass inclined at 55°) is placed in front of the lens of the camera, only a portion of skylight is obtained, while the light of the clouds remains unaltered, and the increased contrast renders it an easy matter to obtain a good picture. But at the same time, this method possesses inconveniences. The proportion of polarised light is far from being the same in all parts of the sky; hence it is not possible to photograph clouds in any direction. Moreover, many photographers object to the complications which are

FIG. 1.—Cirrus Cloud preceding a Storm (March 31, 1892).

involved in the introduction of an analyser in front of the lens of the camera.

There is still another method, unquestionably the most simple one, and the one which, at the same time, gives the best results: it is the employment of coloured screens. In front of the lens of the camera is placed a a screen which transmits yellow and green rays, but is opaque to blue and violet rays. The light of clouds is rich in yellow and green rays; hence a large proportion of it is able to traverse the screen, and act upon the photographic plate, while, on the other hand, the blue background of the sky emits very little yellow light; in fact, the proportion of rays of this refrangibility decreases as the blue colour increases in depth, so its action upon the sensitive film is considerably diminished or altogether obviated. The only inconvenience of this method is that yellow and green rays have very little action upon an ordinary photographic plate. Under these circumstances it would be necessary to give a very long exposure, which is impossible in cloud photography on account of the movements of the objects and the rapid changes of form. It is probably for this reason that coloured screens, which were adopted in the earliest stages of cloud photography, appear now to have almost been abandoned. But this difficulty has been practically overcome by the production of the orthochromatic or isochromatic plates of commerce, which are sensitive to yellow and green light.

FIG. 2.—Cirrus and Cirro-cumulus (February 19, 1893.)

M. Angot finds that the best brands of plates for use in cloud photography are the Lumière orthochromatic and Edwards' isochromatic. Other brands have been tried, but none gave better results than these. As to the yellow screen, the best is obtained by placing a cell having parallel faces, about five or seven millimetres apart, in front of the lens, and filling it with an almost saturated solution of bichromate of potash to which a few drops of hydrochloric or sulphuric acid have been added. A mixture of saturated solutions of bichromate of potash and copper sulphate in the proportion of three of the former to one of the latter may also be employed. In either case the cell is hermetically sealed, and it can easily be fixed in front of the lens or behind it in the bellows of the camera.

Evidently it would be simplest to use a screen of coloured glass, and, as a matter of fact, certain glasses give as good results as the cell containing one of the above-mentioned solutions. But most yellow glasses are quite inadequate for the purpose. It is to be hoped that coloured-glass manufacturers will soon make a glass which will transmit exactly the same rays as the solutions. It will be a good thing to have a series of glasses of graduated tints; the clearest to serve for very bright white clouds standing out boldly upon a fine blue sky, while the darkest could be used for faint clouds when the blue colour of the sky is not so pronounced. The time of exposure must, of course, be increased as the glass used is increased in tint.

The two illustrations here given are reduced copies of two of M. Angot's negatives. The originals are eighteen centimetres long by thirteen wide.

Fig. 1 was obtained on March 31, 1892; it shows some patches of cumulus cloud, and an extremely remarkable sheaf of cirrus which preceded a violent storm by two hours. The second illustration (Fig. 2) shows a form intermediate between cirrus, properly so called, and cirro-cumulus, observed on February 19, 1893. Both these pictures were obtained by means of Lumière orthochromatic plates, with a cell containing a solution of potassium bichromate and copper sulphate, and a wide angle lens having a focal length of 0·160 metres. The aperture was cut down by means of a diaphragm of about one-twentieth the focal length, and the time of exposure for Fig. 1 was three-quarters of a second, and one-half a second for Fig. 2. The usual developers may be employed, but pyrogallic acid was used by M. Angot on account of the latitude of exposure it permits.

As photography is being widely used in the future to increase our knowledge of clouds, it is recommended that the date and hour of exposure be written upon each picture. M. Angot's photographs are a sufficient testimony of the excellence of his method of work, and their multiplication in different parts of the world would considerably extend our knowledge of cirrus clouds, and very probably prove of use in forecasting weather.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Directorship of the British Institute of Preventive Medicine.

THE position of Director of the above-named Institute is one which corresponds to that of M. Pasteur in Paris, and to that of Dr. R. Koch in Berlin, and is therefore one of great importance.

The Institute is now about to be built, and it is of the utmost consequence that the first holder of the office in question should be very carefully chosen, as he will necessarily have a great deal to do with the arrangement of the plans of the laboratory, and the organisation of the work to be done in it. The Institute is intended to do in England the work done in France by the Institut Pasteur, and in Germany by the Berlin Hygienisches Institut; and the Council have already in their hands sufficient money to begin to build and carry on a laboratory on a scale comparable to that of the great continental ones referred to.

The Directorship is a scientific post, and there are certain customs regarding the election to such offices which it is, in my opinion, extremely unwise to neglect.

It is customary, for example, to advertise that such a post is vacant, and to examine the qualifications of the candidates who apply for the office. These and other customary modes of procedure having without sufficient reason been disregarded at a recent meeting of the Council of the Institute, I feel constrained to make a public protest.

Since the Institute was first initiated at my suggestion on December 5, 1889, the meetings of the executive committee and Council have been very ill-attended, a fact for which I believe the office-bearers have been mainly responsible; the result, in any case, being that the officers of the Council have gradually come to control the decisions of the meetings to a much greater extent than I have experienced in any council, syndicate, or board of which I have been a member.

While I was one of the hon. secretaries of the council, I noted what seemed to me grave irregularities in the mode of conducting the business of the council, against some of which I protested in writing to Mr. Ernest Hart (who had occupied the chair at the previous meeting), and verbally to Sir Joseph Lister, who then, as now, was chairman of the Council. Mr. Ernest Hart disclaimed all knowledge of or sympathy with the measures to which I objected, but our chairman not seeing the full point of my protests, I emphasised my strong disapproval of the measures in question by resigning my post of Hon. Secretary.

On Monday, the 11th ult., I received a notice, signed by the Hon. Secretary (Dr. A. Ruffer), calling a meeting of the Council of the Institute for December 13, with the agenda (which I append) containing, amongst formal business, the statement that the "report of committee appointed at last meeting" would be considered.

At the Council meeting of December 13, I saw for the first time a copy of the report in question. This, with the instructions to the committee which supplied the report, I append. The question was at once asked why a report concerning a subject of this importance, had not been, as is customary, distributed to members of the Council before the meeting, seeing that there are among the Council gentlemen who are directors of laboratories, whose aid in considering so important a subject must be of the utmost value, but which could not be given without time to consider the hastily drawn up and imperfect report submitted to the meeting?

To this it was replied from the Chair that the matter was considered so pressing by the office-bearers, that there had been no time to send round copies. As the Institute has been four years reaching its present position, during the whole of which time the office-bearers knew that a Director would have to be appointed, this reply did not appear to me to carry any weight with it. To the question why, assuming for the moment that the adoption of some such report were pressing, its nature had not been clearly indicated in the agenda, in order that those members of Council whose opinion would be of special value in discussing it, might try to arrange, even at some sacrifice, to be present. To this no satisfactory answer was given. As less than a third of the members of the Council were present at the meeting, I, and others, strongly urged that the consideration of the report be adjourned for, say, a week, in order that it might be distributed in the usual way. This being opposed by the two office-bearers present, viz. the Chairman and the Treasurer (Sir H. Roscoe), was not agreed to, their opinion in such a matter necessarily carrying great weight.

If the appended report be examined, it will be seen that the instructions to the committee give no authority to nominate a Director. This view was upheld by one of the members of Council present, who had been appointed member of the committee, but had been unable to be present at its meetings (although that is obviously not the view of the members of committee who signed the report). The Council decided, however, to leave out the name of the Interim Director from Clause 1 of their report. The report so modified was then considered, and although I and others expressed strong disapproval of its being pressed forward without due consideration by the Council, it was, with a few verbal alterations, adopted.

It was then proposed to add to it a tenth clause nominating the Hon. Secretary to the Directorship. It was objected, however, that such a nomination could not be appended in this way to the report, and this objection was upheld by the Council.

The motion was still, however, pressed forward by the signers of the report, which was, as I take it, hopelessly irregular, and which was strongly objected to. It was urged that notice of such a motion should have appeared on the agenda; that the committee had not apparently made any inquiries as to possible candidates, or their qualifications for so important a post; that they had no authority to nominate any candidate, and were therefore acting *ultra vires* in doing so; that in proposing to elect one of themselves in this irregular manner the two office-bearers present were exposing their action to serious misconstruction. In spite of these and other protests, which I need not detail, the motion was pressed, and was eventually formally proposed, seconded, and carried.

I will not seek to state the arguments advanced by our Chairman and Treasurer for their action as office-bearers, seeing that these can be best stated by themselves; nor will I do more in the meantime than mention that on leaving the Council meeting I at once protested in writing to the Chairman, and have since done my utmost to get the election rescinded.

It is unnecessary for me to make more than one or two comments on the above-stated facts. The legality of the election in question may reasonably be doubted, as members of Council had not sufficient notice that it was to take place. There can, however, be no doubt as to the harm to science in the election to a scientific post being carried out in this manner. I am also of opinion that, independently of the manner of conducting it, the election itself was a grave mistake in so far as the interests of the Institute are concerned.

CHARLES S. ROY.

Pathological Laboratory, Cambridge, January 8.

[APPENDIX.]

Agenda of Meeting of December 13, 1893.

1. Completion of purchase of site.
2. Appointment of building committee.
3. Sealing of deed with college of State medicine.
4. Report of committee appointed at the last meeting.
5. Memorandum to be addressed to the trustees of the Berridge bequest.

REPORT OF THE COMMITTEE APPOINTED AT THE LAST MEETING OF THE COUNCIL.

The committee appointed to consider the appointment of the director, his duties and salary, and his relations to the council and staff of the institute, met on December 12, 1893.—Present: Sir Henry Roscoe, Professor Victor Horsley, and Sir Joseph Lister.

They beg to report as follows:

1. That Dr. Ruffer be appointed interim director of the institute for a period of three years, at a salary of £200 a year.

2. That Dr. McFadyen receive the title of lecturer on bacteriology and that he be entrusted with the systematic instruction in that subject.

3. That the director and the lecturer on bacteriology should

have each his own laboratory and rooms where research may be conducted under his supervision.

4. That the scheme of any course of lectures delivered at the institute, whether by the director, the lecturer on bacteriology, or anyone else whom the council may appoint, be submitted to the council for their approval.

5. That the director should exercise a general supervision over the conduct of the institute, and be responsible for it to the council.

6. That all matters of expenditure at the institute should pass through the hands of the director, and that he should be entrusted with the appointment and dismissal of the servants of the institute.

7. That anyone desiring instruction at the institute, or wishing to engage in original research there, should make application to the director, who should have power to admit him.

8. That the director should present to the council a quarterly statement of the work carried on at the institute, and furnish a written annual report.

9. That leave of absence be granted by the council to the director and the lecturer on bacteriology, on the understanding that in each case an efficient substitute, approved by the council, be provided.

(Signed) H. E. ROSCOE.
VICTOR HORSLEY.
J. LISTER.

Electromotive Force from the Light of the Stars.

ON the invitation of Mr. W. E. Wilson, I came here a few days ago for the purpose of trying whether it was possible or not to obtain measurable electromotive forces from the light of the planets and of the fixed stars. The sensitive cells which we employed are seleno-aluminium-cœnanthol cells, and (excepting the liquid) are the same as the seleno-aluminium-acetone cells which I described in the *Phil. Mag.* for March, 1892.

Last night was the only one on which observations were possible; and, owing to the state of the weather, it does not seem likely that, in the time at our disposal for joint-work, any more photo-electric measures can be made. The result of last night's work is to prove that the electromotive force of starlight is easily measurable.

The electrometer which we employed is Clifton's form of the quadrant electrometer of Lord Kelvin. It was placed in a room beneath that in which the telescope is fixed, and was thus kept quite dry and free from draughts. The telescope is Mr. Wilson's two-feet reflector; and the photo-electric cell, attached to a cell-carrier, was connected with the telescope in place of the eye-piece, and could be moved into or out of the image of the star at pleasure. The poles of the cell were connected with those of the electrometer by naked but well insulated fine wires led through a hole in the floor of the observatory. The area of the sensitive plate in the cell is about 3 square millimetres.

An E.M.F. of 1 volt was represented by 460 divisions of the scale, and the light of Venus gave about 40 divisions. Only about one quarter of the disc of the planet is at present illuminated, so that the E.M.F. of the whole light of the planet would have been represented by 80 divisions. [The square of the E.M.F. is proportional to the incident energy.] Thus the light of Venus concentrated by this telescope is represented by about ·17 volts.

With Jupiter about 14 divisions on the scale were obtained; but no conclusion can be drawn from this, because the image of Jupiter covered much more than the area of the sensitive plate. Hence the energy of his light corresponds to a much larger number than that given.

From the light of Sirius we obtained an E.M.F. of about ·02 volts (a little over 9 divisions on the scale).

An attempt on Aldebaran was not productive of any certain result, and was interfered with by an accident to the cell.

However, we consider that we have succeeded in our object, and we hope that, with a slightly improved cell-carrier and a much more sensitive electrometer, results will be obtained from the lights of a large number of fixed stars.

I would observe, in conclusion, that the relative values of the lights of Venus and of Sirius as given in the "Encyc. Brit." ("Photometry"), are most probably erroneous. It seems to me that the light of Venus very much exceeds the value there given. GEORGE M. MINCHIN.

Daramona House, Westmeath, January 8.

THE THYROID GLAND.

(WITH APOLOGIES TO MRS. HEMANS).

"WE hear thee speak of the thyroid gland,
But what thou say'st we don't understand;
Professor, where does that acinus dwell?
We hashed our dissection, and can't quite tell.
Is it where the macula lutea flows,
And the suprachoroidal tissue grows?"
—"Not there, not there, my class!"

"Is it far away where the bronchi part,
And the pneumogastric controls the heart?
Where endothelium endocardium lines,
And a subpericardial nerve intertwines?
Where the subpleural plexus of lymphatics expand?—
Is it there, Professor, that gruesome gland?"
—"Not there, not there, my class!"

"I have not seen it, my gentle youths,
But myxœdema, I'm told, it soothes.
Landois says stolidly, 'functions unknown':
Foster adopts an enquiring tone.
Duct does not lead to its strange recess.
Far below the vertex, above the pes,
It is there, I am told, my class!"

R. M.

NOTES.

PROF. ERNST HAECKEL completes his sixtieth year on February 16 next. On the following day a marble bust of him is to be placed in the Zoological Institute at Jena. Dr. Richard Simon, of Jena, is the treasurer for the fund opened for this purpose, and the following Englishmen are on the general committee:—Mr. F. Darwin, Dr. Gadow, Prof. Huxley, Prof. Ray Lankester, Sir John Lubbock, Prof. Alfred Newton, Mr. Poulton, Mr. Adam Sedgwick, Mr. Sollas, Mr. Herbert Spencer, and Sir Wm. Turner.

THE competition for the prize of 500 francs, founded by De Candolle for the best monograph on a species or a family of plants, has been opened by the Société de Physique et d'Histoire Naturelle of Geneva. The memoirs may be written in Latin, French, German, English, or Italian, and should be sent to the President of the Society before January 15, 1895. Members of the Society are not admitted into the competition.

M. MAREY has been elected vice-president of the Paris Academy of Sciences for the ensuing year.

THE death is reported, at Vienna, on December 2, 1893, at the age of 62, of Dr. J. Boehm, well known for his researches on the circulation of the sap in plants.

THE death is also announced of Baron K. von Küster, eminent in botanical circles; of M. Quinquand, known for his investigations on nutrition and toxicology, and other important physiological works; and of Dr. Heider, Privatdocent in Hygiene in Vienna University.

WE regret to record the death of Herr W. von Freeden, which occurred at Bonn, on the 11th inst., after a short attack of inflammation of the lungs. Herr v. Freeden is best known to science as the founder and first director of the Norddeutsche Seewarte of Hamburg, which in 1875 was developed into the Deutsche Seewarte, under Dr. George Neumayer. Herr v. Freeden was born at Norden, in Hanover, in 1822; he was first appointed Teacher of Physics and Modern Languages at the Gymnasium at Jever, a post which he exchanged for the Headmastership of the Navigation School at Elsfleth, near

Bremen. During his stay at Elsfleth he took an active part in the founding of the North German Lloyd's Company. In 1867 he resigned his position, and moved to Hamburg, where he established the Norddeutsche Seewarte, and in connection therewith organised the first system of storm warnings for the German coasts. The activity of this institution, which existed under the above title for eight years, was most creditable to its management. In February, 1875, the organisation was taken up by the Imperial Government, and Dr. v. Freeden was relieved of his office. He retired to Bonn, where he occupied himself with editing the *Hansa*, a nautical newspaper which he had started. He was for five years from 1871 Member for Hamburg of the Reichstag, but he declined re-election on removing his residence to Bonn.

THE *Kew Bulletin* says that Mr. W. Scott has been appointed Director of Forests and Botanical Gardens in Mauritius, in succession to Mr. J. Horne, who has recently retired.

DR. W. MIGULA has been appointed Professor of Botany at Karlsruhe Technical High School, Dr. W. Laposchnikoff Professor of Botany in Tomsk University, Siberia, and Dr. Zelinka Extraordinary Professor of Zoology in Graz University.

THE medals and funds to be given at the anniversary meeting of the Geological Society of London to be held on February 16 next, have been awarded as follows:—The Wollaston Medal to Prof. Karl A. von Zittel; the Murchison Medal to Mr. W. T. Aveline; the Lyell Medal to Prof. John Milne, F.R.S.; the balance of the proceeds of the Wollaston Fund to Mr. A. Strahan; that of the Murchison Fund to Mr. G. Barrow; that of the Lyell Fund to Mr. William Hill; and a portion of the proceeds of the Barlow-Jamieson Fund to Mr. Charles Davison.

DR. E. SYMES THOMPSON will deliver four lectures at Gresham College from January 22-26, his subject being "The Sense of Touch."

THE forty-seventh annual general meeting of the Institution of Mechanical Engineers will be held on February 1 and 2, when the President, Dr. William Anderson, F.R.S., will retire, and will be succeeded by Prof. A. B. W. Kennedy, F.R.S.

A COMPLETE skeleton of a Plesiosaurus, about 3¼ yards long, has been found, with other fossil remains, at Holzmaden in Würtemberg. It is being taken to the Berlin Museum.

PROF. CARR informs us that a very extensive and valuable collection of British and foreign plants has been presented to the Nottingham Natural History Museum by Mr. H. Fisher, late of Newark. Some idea of the nature and extent of the collection may be gathered from the following enumeration of the more important series included in it: (1) A practically complete herbarium of British plants, comprising about 2000 species and varieties, and about 10,000 specimens. (2) A European collection, comprising many thousand species from France, Germany, Switzerland, Austria, Roumania, Russia, Norway, Sweden, &c. (3) Several thousand species from North America. (4) A very fine collection from the Bombay Presidency. (5) About 1500 species from Natal, the Transvaal, and other plants of South Africa. (6) A small collection from Australia. Of the above collection that from Russia is of quite exceptional value and interest. It comprises species from all parts of the Russian Empire—from St. Petersburg, Lapland, and the Crimea, through Siberia to Kamskatka and Turkestan, also from the Trans-Caucasus and the Caspian region. The Spanish collection is an extremely fine and valuable one—probably one of the best in existence. In order to hand over the collection to the town in as complete and accessible a form as possible, Mr. Fisher is himself arranging and labelling the collection.

MUCH has been written and conjectured as to the origin of music, and the rhythmical movement of the body which is intimately associated with musical sounds. Dr. S. Wilks, F.R.S., discusses this problem in the January number of the *Medical Magazine*. He points out that it is felt by many that the origin admits of a physiological explanation; but others prefer to regard music as a purely spiritual faculty. All, however, who have considered the nature and origin of music believe that rhythm, as exemplified by movement, is very closely connected with it. The latest work on primitive music is by Wallaschek, and the conclusion he arrives at is that rhythm, or keeping time, lies at the very foundation of the musical sense. But rhythm and the time sense can be referred to muscular contraction and relaxation, for it has been long maintained by physiologists that the muscular sense is the measure of time, and intimately bound up with the idea of music. As Dr. Wilks remarks, there must be an up and down movement or rhythm in all muscular action, and this seems to be the same thing as the sense of time or rhythm of which Wallaschek speaks. In fact, the rhythmical sense insisted on by Wallaschek as the basis of music is, in all probability, the muscular sense which physiologists believe to form an intimate part of the musical faculty. Not in the different passions of the mind, but in muscular action, therefore, music appears to have had its origin.

THE internal temperature of trees has formed the subject of some investigations by M. W. Prinz (*La Nature*). The results show that the mean annual internal temperature of a tree is practically the same as that of the surrounding air, but the monthly means differ by two or three degrees. In general it takes a day for a thermal variation to be transmitted to the heart of a tree. On some days the internal temperature differs by as much as 10° C. from the air outside, but generally the difference is only a few degrees. When the air-temperature falls below the freezing point, the internal temperature of a tree descends to a point near that at which the sap freezes, and appears to remain there. The maximum temperature of the interior of the trunk of a tree may occur some time before the maximum is reached by the surrounding air, owing to the action of the spring sun upon the tree while devoid of foliage. During the high temperatures of summer, the internal temperature was proved by the investigations to be about 15° C. with a variation of 2° C. at the most. Speaking generally, a large tree is warmer than the air in cold months, and a little colder than the air during the summer months.

DURING the recent frost, large masses of ice containing numerous freshwater eels were carried down the River Arun to Littlehampton. This affords an interesting example of the manner in which freshwater fish in a perfect state of preservation may be buried in some number in marine deposits.

MR. J. STIRLING, in his second special report on the Victorian Coal-fields, describes the various areas in detail, referring amongst other points to littoral and subaerial denudation and to the origin of soils. In the Kilcunda district numerous boreholes for coal have been put down by Government—one to a depth of 1158 feet.

MR. J. J. STEVENSON, in the *Bulletin* of the Geological Society for America, vol. v., discusses the origin of the Pennsylvania anthracite, and shows that there is no relation between the amount of disturbance of the strata and the production of anthracite. The coal becomes more anthracitic as the seams thicken towards the north-east; in this direction the coal seam, whilst in process of formation, would be longer exposed to chemical change.

DR. W. F. HUME read a paper on "The Genesis of the Chalk" before the Geologists' Association on January 5. He showed that, viewed in its general aspect, the Chalk Period bears evidence of the almost continuous gain of elevation over depression influence. According to his researches, the Upper Greensand is the expression of coast-line conditions, the currents transporting shore material being sufficiently strong to make their influence felt over 150 miles from land. The chloritic marl probably represents the denuding effect of the advancing sea upon the sinking land. The chalk marl and grey chalk seem to have been deposited in areas of gradual subsidence; judging from the change in the Foraminifera, the gradual reduction in size and quantity of quartz and glauconitic grains, and the absolute disappearance of heavy minerals (zircons, &c.) in the higher zones of the Lower Chalk. The great purity of the chalk in the *Terebratulina gracilis* zone, and the almost entire absence of a heavy residue, indicates that the maximum depression for the Middle Chalk period very probably occurred about the time of the laying down of its central beds. From this zone onwards the chalk becomes more and more marly, passing finally into the condition of the chalk rock, that is, a truly nodular bed. The reappearance of quartz and glauconite grains, and heavy minerals (Tourmaline, Augite, and Hornblende), all point to this rock as having been formed during a period of elevation. The zones of the Upper Chalk show typically the continuation of great depression, for the flints gradually become reduced in size, and pass through various changes of shape, that is to say, from irregular to zoned, and finally to the tabular form.

AN important experimental research on the "Decomposition of Liquids by Contact with Powered Silica," was described by Dr. G. Gore at a recent meeting of the Birmingham Philosophical Society. The method of experiment employed was simply to take 25 centims. of a solution of an acid, salt, or alkali, of known composition, which had no chemical action upon pure precipitated silica (or other suitable insoluble powder), in a stoppered bottle; add to it 50 grains of the powder, thoroughly agitate the mixture, set it aside, usually about sixteen hours, and analyse the clear liquid portion. This enabled the chemical composition of the film of liquid which adhered to the powder to be approximately ascertained, and the influence of surface tension upon such composition to be examined. The experiments show that the chemical composition of films of liquid adhering to solids may be approximately ascertained by this method. They further show that the power of abstracting dissolved substances from liquids is a common property of finely divided solid bodies, and that the amount abstracted varies with the kind of powder employed; the degree of fineness of the powder, and consequently the amount of its surface; the kind of dissolved substance; the proportion of powder to dissolved substance; the kind of solvent; the proportion of solvent to powder; the proportion of dissolved substance to solvent; and, in a small degree, with the temperature. The union takes place quickly, and a long period of time has but little influence. Finely precipitated silica possesses the property in the greatest degree, and alkaline substances are the most affected; with very dilute alkaline solutions more than 80 per cent. of the dissolved substance was abstracted by the silica. The results appear to throw some light upon the purification of water by filtration through the earth and upon agriculture, and to show that the alkaline constituents of soils are retained much more by the silica than by the alumina. The effects of silica upon weak solutions of potassium cyanide indicate that the great loss of the latter substance in the commercial process of extracting gold and silver from powdered quartz is largely due to the "adhesion" of that salt to the silica. And the results obtained with silica and a very weak solution of iodine indicate a possible method of extracting the latter substance from solutions, and the recovery of the iodine from the silica by distillation. The research brings more closely together the subjects of physics and chemistry.

THE *Analele* of the Roumanian Meteorological Institute, vol. vii., contains an account of a glazed frost, or smooth coating of ice, which occurred on November 11 and 12 last over a very large tract of country, and caused much damage to trees and telegraph lines; some of the trees had not only their boughs, but even their trunks broken by the weight of the deposit. Dr. Hepites states that in this case the cause of the formation of the glazed-frost was not that the rain fell upon objects at a temperature below zero, as the phenomenon has sometimes been explained, but that it is probable that the drops of rain were in a state of superfusion, and became frozen on touching the objects on which they fell. When the glazed-frost commenced, the temperature on the ground was 36°·5. In the neighbourhood of Bucharest the telegraph wires were coated with ice an inch in diameter, and were thickly studded with stalactites of ice. The weight of this coating over the length of a metre of the wire was thirteen times as heavy as the wire itself.

THE numerous attempts which are at the present time being made to utilise the energy which runs to waste wherever there is a waterfall, and which have lately had considerable public attention drawn to them on account of the publication of Prof. Forbes' paper on the utilisation of the Niagara Falls, have received an interesting addition in the attempt that is being made on the canal between the Seine and Saône. It occurred to M. Galliot, an engineer at Dijon, to utilise the water power of the fall of water at the lock sluices to drive turbines and dynamos, the current obtained being used to propel the boats on the canal. The electric power is conveyed along the canal by means of a wire supported on posts, and each tow-boat is provided with a motor which takes its current from this wire. The propulson of the tow-boat is effected, not by means of a screw propeller on the boat, but by a train of gear wheels connecting the motor to a chain which extends along the bottom of the canal, and by means of which the boat drags itself along. In addition to working the canal boats, the electric power is utilised to light up the interior of a tunnel through which the canal passes.

A PROPOSAL for a standard of "normal air" is made by M. A. Leduc in the *Comptes Rendus*. It is to be one litre of air taken at a place outside any town in a level country, and during calm weather. Freed from carbonic acid and water vapour, as well as traces of other accidental gases, such a litre of air would contain 23·2 per cent. by weight of oxygen. Since this proportion is variable in the same place by about 4 units in the second decimal place, it is useless to determine the weight of this litre of air to within more than 1/10000 of its value. A careful series of determinations gave 1·2932 gr. for this weight at 0° C., at the latitude of Paris, and at 760 mm. pressure. Under 1 C.G.S. atmosphere, this weight would be 1·2758 gr. This standard would be sufficiently well defined for most practical purposes, but where greater accuracy is required, M. Leduc proposes to employ nitrogen as a standard of reference for gas densities. The weight of the normal litre of nitrogen at Paris is 1·2570 gr., or 1·24 gr. under 1 C.G.S. atmosphere, within 0·1 mgr.

THE *Journal de Physique* for December contains a paper by M. Violle, on the electric furnace and the light given out by, and the temperature of, the electric arc. In a former note a description of the form of furnace used by M. Violle has been given. The author considers that his experiments show that the electric arc is the seat of a perfectly definite physical phenomenon, namely, the ebullition of carbon, for the arc is characterised by a constant brightness (*i.e.* the light given out by a given area of the positive crater is constant), and by the temperature being always the same, as well as by all the circumstances which characterise normal ebullition. The constancy of the character of the light given out by the arc has been noted by Abney and Festing, who have adopted it as the standard of white light, and the author's observations show that whatever be the watts consumed in the lamp, the brightness remains constant. This he has shown by direct comparison with a standard light, and also by photographing the positive carbon, when the density of the image remained constant.

PROF. S. P. LANGLEY, who has recently been giving a large amount of attention to ærodynamics, contributes a remarkable paper to the current *American Journal of Science* on what he calls "The Internal Work of the Wind." The conclusions attained in this paper lead the author to the confident assertion of the mechanical and practical possibility of a heavy body, provided with suitable plane or curved surfaces, being suspended indefinitely in a wind, or even advancing against it without connection with the ground or the expenditure of internal energy. This is to be brought about by utilising the heterogeneous structure of wind, which Prof. Langley shows to consist of puffs succeeding each other several times per minute. This was proved by the records of some very light anemometers with paper cups, mounted on the roof of the Smithsonian Institution, at 153 feet above the ground. The electric record was made at every half revolution. In one case a wind of 23 miles an hour rose within 10 seconds to a velocity of 33 miles an hour, and fell to its initial speed in another 10 seconds. It then rose within 30 seconds to 36 miles an hour, and so on, passing through a series of maxima and minima separated by intervals of about 10 seconds, and sometimes stopping altogether. This observation may serve to solve the long-discussed problem of the soaring of birds. A wind acting against a free plane at a suitable angle will urge it upwards until the plane has assumed the velocity of the steady wind. If the wind-velocity is then reversed, absolutely or relatively, and the inclination of the plane is reversed at the same time, the plane will be urged still further upwards, and the more so the greater its weight. If a heavy body can thus rise, it follows at once that it can also advance against the wind if not too strong, by utilising the energy thus acquired, and descending in the direction whence the wind blows. The main difficulty in constructing a contrivance to effect this would lie in the adjustment of the inclination to a varying wind, but Prof. Langley is confident that this difficulty will not prove insuperable.

THE alleged discovery of the northern end of Greenland in the Nordenskiöld Inlet seems to have been based upon a very bold interpretation of Peary's observations. Peary himself has, in his first account, said nothing about having discovered a passage from Nordenskiöld Inlet to Independence Bay, and the report now issued by his companion, J. Astrup (*Geogr. Selsk. Aarbog*), which gives particulars of what was actually observed, does not allow any conclusion as to a waterway connecting them. It would be strange indeed if Astrup left the discovery of the north end of Greenland unmentioned, as if it were something unessential.

AN ingenious method for making permanent microscopic preparations of particular colonies on a gelatine plate, has been recently devised by Hauser (*Muenchener med. Wochenschrift*, 1893, No. 35). It was found that when exposed for some time to the vapour of formalin, gelatine becomes so rigid that no temperature is able to melt it; even submitting it to the heat of a bunsen flame, or boiling it in a soda solution, fail to liquefy it. This formalin-gelatine becomes, moreover, strongly antiseptic, for when freely exposed to the air no colonies make their appearance, and neither will those organisms grow which are purposely introduced into it. Gegner, in an earlier number of this journal, states that although solutions of formalin had a bactericidal action, the vapour was a far more powerful antiseptic; this investigator also notes that gelatine exposed to this vapour would not melt at 37° C. To prepare bacterial colonies for microscopic examination, Hauser takes a thin film of the solid gelatine containing the particular growth required, and places it on an object glass, and, superposing a cover-glass, seals it from the outer air by a rim of melted gelatine. The preparation is then placed in the formalin chamber for twenty-four hours, during which it becomes quite solid, and on being removed may be further protected by a border of sealing-wax. If it is desired to stain the colonies before the formalin process, the gelatine film should be immersed for twenty-four hours in a weak aqueous solution of fuchsin, by which means the bacterial growth becomes fairly strongly coloured, whilst the gelatine itself only assumes a much paler hue.

WE have received the 1894 *Annuaire* of the Brussels Académie Royale des Sciences, des Lettres et des Beaux-Arts.

"THE Elements of Co-ordinate Geometry," Part 1, by W. Briggs and G. H. Bryan (Univ. Corr. Coll. Press), has reached a second edition.

A THIRD edition, enlarged and revised, of Dr. T. Dutton's little book on "Indigestion" (Kimpton, and Hirschfeld Bros.) has been published.

MR. WILLIAM CLAY, Edinburgh, has issued a new catalogue, No. 60, of standard second-hand and new books on physical science offered for sale.

DR. H. WAGNER gives an account, in the *Oesterreichische Botanische Zeitschrift*, of his botanical exploration of the Balkans, in company with Herr J. Stipanics, entomologist.

THE *Journal of Anatomy and Physiology* for January contains an article by Mr. A. Keith, on the ligaments of the Catarrhine monkeys, with references to corresponding structures in man. Profs. J. C. Ewart and A. Macalister are among the other contributors to the number.

THE first part is published of Dr. H. Trimen's "Handbook to the Flora of Ceylon," containing descriptions of all the species of flowering plants indigenous to the island, and notes on their history, distribution, and uses. It is issued under the authority of the Government of Ceylon.

THE Calendar just issued by the Department of Science and Art contains the following names of recently appointed Inspectors of Science and Art Schools:—Dr. E. J. Ball, R. Blair, S. F. Dufton, C. Geldard, Dr. H. H. Hoffert, D. E. Jones, Dr. MacNair, C. McRae, T. Preston, F. Pullinger, Captain T. B. Shaw, R.E., and H. Wager.

THE National Footpath Preservation Society, of which the late Prof. Tyndall was a member, has issued its ninth annual report. The large number of cases of footpath interference, encroachments, &c. described in the report, shows that the society exerts a salutary influence upon those who are inclined to disregard ancient rights.

SUBSCRIPTIONS are invited by Laidley and Co., of Port Elizabeth, to the issue of a complete botanical collection for the Cape Colony, Kaffraria, Natal, Zululand, Swazieland, Matabeleland, Bechuanaland, Mashonaland, the Transvaal, Orange Free State, and the Portuguese territories of the Zambesi. The flora is computed to exceed 20,000 species.

MESSRS. BLACKIE AND SON have sent us several of their Guides to the Science Examinations of the Department of Science and Art. The books contain some useful hints to intending examinees, and answers to questions that have been set at the Departmental examinations. A number of test-papers in mathematics, arranged by Mr. R. Roberts, has also just been published by Messrs. Blackie.

"LA Terre avant l'apparition de l'Homme" (MM. Baillière et Fils) is a bulky tome by Prof. F. Priem, in Brehm's *Merveilles de la Nature* series. In it the author recounts the numerous changes through which our globe has passed in geological time. He describes the distribution of land and water during the well-marked periods of this world's history, and deals particularly with the fauna and flora of bygone days. In the latter half of the work, the geology of France is dealt with in a very detailed manner. The book is *au courant* with recent investigations in geology and palæontology; it contains 850 figures illustrating fossils, geological sections, picturesque regions and interesting formations, and is worthy of a high place in the fine series to which it belongs.

During the last few months we have had the pleasure of commenting upon several chatty books on natural history matters—books in which instruction is happily combined with interest. Another volume of a similar kind, "Random Recollections of Woodland, Fen, and Hill," by Mr. J. W. Tutt (Swan Sonnenschein and Co.), has recently been published. We recommend the book to the nature-lover and entomologist because it contains a large amount of information brightly put and generally accurate; and all who can appreciate the beauties of natural creatures and things would do well to read it.

A VERY important collection of works is being offered for sale by Messrs. W. Wesley and Son. We refer to the Paracelsus Library of Dr. E. Schubert, who died at Frankfort-on-the-Main in 1892. The library contains 194 editions of the writings of Paracelsus, 548 works which partly or chiefly treat of Paracelsus, description of his times and the places where he worked, publications of his friends and opponents, and a selection of 351 works on alchemy. Altogether this unique collection comprises about eleven hundred books, manuscripts, portraits, and tracts, and it is richer in original editions of Paracelsus than that of the British Museum. It is satisfactory to know that no part of the library will be disposed of separately, with the exception of the portion on alchemy.

AN investigation of the mechanics of the interaction of ethyl alcohol and hydrogen chloride is communicated from Prof. Lothar Meyer's laboratory to No. 12, 1893, of the *Zeitschrift für physikalische Chemie* by Mr. Cannell Cain. Solutions of hydrogen chloride of different strengths were obtained by leading the dry gas into the dry alcohol, which was coated by a freezing mixture. A definite quantity of such a solution was then sealed up in a small glass tube, and kept for a definite length of time at a constant temperature in a water bath. The composition of the solution before and after the interaction was ascertained by titrating a known amount with dicinormal soda solution. The results show that concentration and time of reaction being the same, the extent of the chemical change increases rapidly with the temperature. Up to 15° there is no appreciable interaction, but in a solution containing 100 equivalents of alcohol and 81 of hydrogen chloride at 80° some 15 per cent., and at 99° some 50 per cent. of the latter enter into combination in one hour. For a given temperature and concentration the amount of decomposition increases with the time at a rate which gradually diminishes, and finally becomes zero. Temperature and time of reaction being the same, it is also shown that increase in the quantity of alcohol in the above solution, or addition of water or ethyl chloride, retard the rate of change. By experiments with water and ethyl chloride the author makes clear the reversible character of the action, and next makes observations to ascertain the relative proportions of the substances present when equilibrium is established. In these experiments various solutions of hydrogen chloride in alcohol, alone, and in presence of different amounts of water are employed. Here it is shown that Guldeberg and Waage's law is obeyed, as the product of the active masses of alcohol and hydrogen chloride bears a constant ratio to the product of those of water and ethyl chloride unless in cases where ethyl chloride separates out, and the solutions thus become heterogeneous. If the alcohol and hydrogen chloride be present in equivalent amounts the results indicate that the equation $C_2H_5OH + HCl + 3C_2H_5Cl + 3H_2O$ approximately represents the condition of things when equilibrium is attained.

IN the review of Mr. Richard Inwards' "Weather Lore," that appeared in these columns on January 4, p. 219, the author's attention was commended to a collection of "wise saws" made for the U.S. Signal Service by Major Dunwoody. Mr. Inwards points out to us that his book contains extracts from this collection, and that he acknowledges his obligations to it in the introduction. We regret that this acknowledgment was overlooked by the writer of the notice.

THE additions to the Zoological Society's Gardens during the past week include two Mozambique Monkeys (*Cercopithecus pygerythrus*) from East Africa, presented respectively by Mr. H. P. East and Mrs. Adams; two Common Marmosets (*Hapale jacchus*) from South-east Brazil, a Common Hamster (*Cricetus frumentarius*) European, presented by Mrs. Brightwen; two Jackdaws (*Corvus monedula*) British, presented by Miss Williams; a Clifford's Snake (*Zamenis Cliffordi*) from Egypt, presented by Mr. W. L. Tod; a Malaccan Parrakeet (*Palæornis longicauda*) from Malacca, deposited; a Snow Leopard (*Felis uncia*) from Lahoul, Punjaub, Himalayas, an Alpine Marmot (*Arctomys marmotta*) European, two Hairy Armadillos (*Dasypus villosus*), a Black-necked Swan (*Cygnus nigricollis*), two Rufous Tinamous (*Rhynchotus rufescens*), two Brazilian Caracaras (*Polyborus brasiliensis*), two Common Teguexins (*Tupinambis teguexin*), a Common Boa (*Boa constrictor*) from South America, a Melodius Jay Thrush (*Leucodioptron canorum*) from China, purchased; two Lapwings (*Vanellus vulgaris*), two Dunlins (*Tringa alpina*) British, received in exchange.

OUR ASTRONOMICAL COLUMN.

SUNSPOTS AND SOLAR RADIATION.—Spectroscopic observations, the discussion of the frequency of tropical cyclones, and cyclical variations of barometric pressure, indicate that the greatest amount of heat is received from the sun by the earth during a maximum epoch of solar activity. But, on the other hand, the discussions of statistics of air temperature and solar radiation suggest that that the sun's heat is greatest when his surface is least spotted. Some new facts in connection with this paradox are described by M. R. Savélief in the current *Comptes Rendus*, and seem to combat the latter result. He has made a large number of observations with a Crova's actinograph since June 1890, and compared them with the late Dr. Wolf's numbers showing the relative frequency of solar spots. A few observations are given indicating that the solar constant increases with the increase of solar activity. M. Savélief has also calculated the mean quantity of heat received on one square centimetre of horizontal surface on the ground during one day, and for an hour of solar radiation. The results obtained by this method, like those deduced from the solar constant, point to the conclusion that the calorific intensity of solar radiation increases with the activity of the phenomena visible upon the surface of the sun, that is to say, with the increase of solar spottedness. These results are diametrically opposed to those obtained by previous investigators (see NATURE, vol. xliii. p. 583), and, if they are confirmed, a real difficulty in the way of explaining the correlation of solar and meteorological phenomena will have been removed.

THE MEASUREMENT OF STELLAR DIAMETERS.—When the objective of a telescope is covered with a screen having two slits in it, the image of the object under observation takes the form of a series of fringes lying in the direction of the slits; and every one with an elementary knowledge of physics knows that this appearance is due to the interference of the beams of light traversing the instrument. Fizeau appears to have been the first to point out that the size of the fringes depends upon the angular dimensions of the luminous source producing them, and that this fact might be utilised to determine stellar diameters. The means by which Prof. Michelson has applied the principle to the measurement of the diameters of Jupiter's satellites has already been described in these columns (vol. xlv. p. 160); but the subject is so important that we give here the gist of a discussion of the theory of the matter, contributed by M. Maurice Hamy to the number of the *Bulletin Astronomique* just issued. By means of Prof. Michelson's interferential refractometer—an instrument with a life of usefulness before it—it is possible to measure diameters down to 0″·01, that is, to the angle which the sun would subtend if it were removed to the distance of α Centauri. In fact, there is little doubt that the diameters of stars are measurable by this means. All that is necessary theoretically is to cover the object glass of the telescope with a screen having two rectangular, parallel slits, equal and of variable width. The interference fringes produced at the focus of the instrument are made to disappear by separating the slits, and when the fringes corresponding to light of a wavelength represented by λ have vanished, the distance (l) between the centres of the slits must be measured. The exact formula which enables the diameter (ϵ) of the object under examination to be determined from these data is, according to M. Hamy,

$$\epsilon = 1''\cdot22 \frac{\lambda}{l \sin 1''}$$

There are, of course, a few difficulties in the way of perfectly realising the theory, but they are being overcome, and it is not too much to say that the interferential refractometer will add very considerably to astronomical knowledge before the end of this century. It would be interesting to measure the diameters of Algol, and some of the spectroscopic binaries, and compare the results with those deduced from observations of motion in the line of sight.

THE MOON AND WEATHER.—The solitary observable effect of the moon on our atmosphere was believed by Sir J. Herschel to be exhibited in the tendency of clouds to disappear under a Full Moon. He attributed this to the heat radiated from the lunar surface. Humboldt speaks of this connection as well-known in South America, and Arago indirectly supports the theory by stating that more rain falls about the time of New Moon than at the time of Full Moon; the former period being cloudy, and the latter cloudless, according to theory. With the idea of obtaining information upon the matter, the Rev. S. J. Johnson has examined the state of the sky at moonrise and at midnight on the day of Full Moon only for the last fifteen years. His results were communicated to the Royal Astronomical Society on January 12, and they confirm the opinion now held by almost every astronomer, viz. that the Full Moon has no effect in breaking up clouds.

GEOGRAPHICAL NOTES.

MRS. BISHOP (Miss Isabella Bird) has set out *via* Canada for Korea, where she intends to spend some time studying the country, and whence she may afterwards make a journey into Manchuria.

THREE Christmas lectures to young people by Mr. Douglas W. Freshfield, were arranged by the Royal Geographical Society, and were delivered in the second week of January to an interested audience. The subject was mountain-study as a branch of geography, and the lectures were illustrated by a large collection of extremely fine photographic views of the Alps and Caucasus.

MR. H. J. MACKINDER commenced the second series of his lectures on the relation between geography and history, in pursuance of the Royal Geographical Society's Educational Scheme, on January 11, in the theatre of the Royal United Service Institution, Whitehall Yard. The lecture was introductory to the present course, which will be continued weekly, and consisted of an epitome of last year's lectures, showing that physical and geographical conditions largely determine the order of history and the movements of peoples. The remaining lectures will deal with a series of concrete examples, focussing the essential features of the relation between the geography and history of the chief countries of Europe, and especially of the British Islands.

THE *Zeitschrift* of the Berlin Geographical Society publishes an interesting paper, by Dr. Wegener, on the Chinese map of northern Tibet and the Lob-nor District, being a sheet of the official Chinese Atlas compiled by the labours of the Jesuit missionaries at the Court of Pekin, who trained and superintended Chinese surveyors. It was first published in 1718, and an enlarged edition appeared in 1863 extending over the greater part of Asia. This work still is the basis of the European maps of many parts of Tibet, and the careful index of names prepared by Herr Himly, which accompanies the report, is of extreme value, as, not content with the Chinese lettering, he has had recourse to the original Tibetan, Turki, and other native names, which he transliterates with great care.

AUGUST ARTARIA, the eminent Austrian map publisher, who has done much to maintain the character of scientific cartography, died at Vienna on December 14, 1893, aged 87.

MM. SCHRADER AND DE MARGERIE, whose long study of the geology of the Pyrenees is well known, have contributed to the last volume of the *Annuaire* of the French Alpine Club a concise discussion of the geographical conditions of the chain illustrated by a large-scale coloured orographical map. The denudation of the northern slope has been much more complete than that of the southern; the tertiary strata remain on the latter, but on the French side have been eroded away to form the vast fans of alluvium of the lower plain. Despite their general form, the Pyrenees are not composed of ranges running east and west, but of mountain knots and short ranges oblique to the general direction running towards E. 30° S. and then turning towards E.N.E. as a rule. The mean altitude of the chain is about 1000 metres, or say 3300 feet. Elie de Beaumont, on the assumption that the southern slope was strictly similar to the northern, made his estimate of the mean height 500 metres greater. The mass of the Pyrenees, if spread over the surface of France, would raise the level of that country by 102 metres, or 330 feet.

A NEW SULPHIDE OF CARBON.

A NEW liquid sulphide of carbon of the composition C_3S_2 has been isolated in a somewhat remarkable manner in the chemical laboratory of the university of Buda-Pesth, by Prof. von Lengyel, who contributes an account of it to the current *Berichte*. In addition to the well-known disulphide of carbon, several other substances supposed to be compounds of carbon and sulphur have from time to time been described; but as they appear to have been amorphous insoluble solids very difficult to purify, there is very little evidence of their being definite compounds. The substance now described, however, appears to be a very well characterised liquid compound of unmistakable odour and corrosive action upon the skin, and capable of being distilled under diminished pressure.

The method of preparing it was accidentally discovered during the elaboration of a number of lecture experiments illustrating the synthesis and decomposition of carbon disulphide. It was long ago pointed out by Berthelot that this familiar substance decomposes at a temperature but slightly higher than that at which its formation from its constituents occurs. Buff and von Hofmann subsequently showed that the temperature of a glowing platinum wire was ample to bring about slow dissociation of the vapour, and that the disruption of the compound occurred very rapidly indeed at the temperature of red-hot iron wire. An experiment was therefore arranged to ascertain whether rapid removal of the vapour of the synthesised compound from the heated sphere of action would largely prevent the loss by dissociation, and in order that the test should be a severe one, the rapidly moving vapour was subjected in its passage to the high temperature of the electric arc. It was during this experiment that the new sulphide of carbon was unexpectedly produced.

A little more than a hundred cubic centimetres of carbon disulphide were placed in a flask arranged over a water bath. A large globe had been previously sealed on to the neck of the flask, through tubuli in which the carbon electrodes were inserted. To a third tubulus of the globe an upward condenser was fitted, the interior tube of which was finally bent downwards to serve as a gas delivery tube. The water bath was then heated and the carbon disulphide maintained in rapid ebullition, the electrodes were approached until the powerful current from accumulators was transmitted, and then withdrawn so as to generate the arc. The electric arc in carbon disulphide vapour under these conditions is a remarkable phenomenon; it is seamed with a dark band passing along its centre from pole to pole, and the brightest spots of the incandescent terminals are just where the band appears to touch them. The carbon disulphide was kept boiling and the arc passing for a couple of hours, during which the globe was filled with the vapour, which condensed in the condenser, and fell back into the flask. The interior of the apparatus soon commenced to blacken with liberated carbon, which collected upon the surface of the liquid, and an extraordinarily strong tear-exciting odour soon made itself evident in the neighbourhood of the apparatus. At the conclusion of the experiment the residual liquid was cherry-red in colour, and was transferred to a closed vessel containing copper turnings in order to remove the free sulphur present. After being thus left for a week it was filtered, and the carbon disulphide evaporated at a low temperature in a current of dried air, in order, if possible, to isolate the substance endowed with the powerful odour. Eventually a few cubic centimetres of a deep red liquid, the new sulphide of carbon, were left, which possessed the odour in greater intensity, a trace of the vapour producing a copious flow of tears, accompanied by violent and persistent catarrh of the eyes and mucous membrane. A drop of the liquid, moreover, at once blackened the skin.

The specific gravity of this liquid is 1·2739, so that it sinks under water, with which it does not mix. When heated it polymerises into a hard black substance. If the rise of temperature is gradual the change occurs quietly, but when rapidly heated to 100–120° the polymerisation takes place with explosive force, the interior of the vessel being covered with projected deposits of the black substance. Analyses both of the liquid and of the black solid indicate the same empirical formula, C_3S_2, and molecular weight determinations of the liquid, dissolved in benzene, by Raoult's method, agree closely with the molecular weight corresponding to that formula. The liquid can be partially distilled at 60° *in vacuo*, a small portion, however, always polymerising. The liquid, moreover, spontaneously changes in a few weeks into the more stable black solid modification. The solutions of the liquid in organic solvents likewise slowly deposit the black form.

The liquid readily ignites, burning with a luminous flame, and forming dioxides of carbon and sulphur. Caustic alkalies dissolve it, forming dark coloured solutions from which dilute acids precipitate the polymerised black compound. With alcoholic potash the action is very violent. A drop of concentrated sulphuric acid causes instant passage to the black form accompanied by a hissing noise. Nitric acid provokes an explosion and ignition, but 70 per cent. acid dissolves it completely and quietly.

The black polymeric modification is readily soluble in caustic alkalies, but acids reprecipitate it unchanged. When heated it undergoes a remarkable change, sulphur subliming, and a gas, inflammable and containing sulphur, but not carbon disulphide, is liberated, the nature of which is reserved for a further communication.

The liquid sulphide combines readily with six atoms of bromine, with evolution of heat. The substance is readily isolated when bromine is dropped into a solution of C_3S_2 in chloroform, as it is insoluble in that solvent. Strangely enough this compound, $C_3S_2Br_6$, is endowed with a pleasant aromatic odour, two substances of frightful odours thus uniting to form an agreeably odoriferous compound, a striking example of the effect of chemical combination.

A. E. TUTTON.

DR. GREGORY'S JOURNEY TO MT. KENIA.

AT the meeting of the Royal Geographical Society on Monday evening, Dr. J. W. Gregory read a paper, of which the following is a full abstract:—

It has long been known that the lakes of Equatorial Africa are developed on two types, first those which have low shores and are rounded in shape, and second those which have high, steep shores and are long and narrow. The lakes of the latter group, moreover, are distributed on a definite plan, occurring at intervals along lines of depression across the country. The chief of these runs from Lake Nyasa through a large series of lakes, including Natron, Nawasha, Baringo and Basso Narok (Lake Rudolf); from the last of these the line of depression runs through Abyssinia into the Red Sea, which continues the same type of geographical structure for 18° to the north; thence it can be followed up the Gulf of Akaba to the Dead Sea and Jordan Valley. It seems not unlikely that the whole of this great line is due to one common earth movement of no very great age, for the traditions of the natives around Tanganyika, of the Somalis and Arabs, and of the destruction of Sodom and Gomorrah may have reference to it. It was the interest which these problems excited that led to Dr. Gregory's desire to visit the district, as he was recently enabled to do, by the permission of the Trustees of the British Museum. He started with a large expedition, intended to explore this "Rift Valley" in the neighbourhood of Lake Rudolf, which landed at Lamu, and thence started up the Tana Valley, where it unfortunately collapsed. On his return to Mombasa Dr. Gregory himself organised a small caravan of forty Zanzibaris, and travelled to the highest part of the "Rift Valley" between Nawasha and Baringo, examining its structure and natural history. The most risky part of the journey was crossing the high plateau of Leikipia, which has only twice before been traversed, by Teleki and Höhnel in 1887, and by the German Emin Relief Expedition under Dr. Peters in 1889–1890. Mr. Joseph Thomson reached its western side, but had to abandon his camp and escape under cover of night. The expedition crossed Leikipia by a new route, and traversing the plateau which is marked as the site of the "Aberdare Mountains," reached Northern Kikuyu without trouble, except for want of food. The natives at first refused to sell any, as some white men who had visited a neighbouring district had seized food without payment, shot the elders, and carried off the young men as porters. After much "shauri" the natives were satisfied as to the peaceful object of the expedition, the right of blood-brotherhood was celebrated, and food obtained. The party then turned north, to the western foot of Mount Kenia. Most of the men were left in the camp while Dr. Gregory and twelve men started for the central peak. Three days were spent cutting a way through the dense forest and bamboo jungle on the lower slope. Owing to the damp, mist, and cold, this work was very severe on the Zanzibaris. On the fourth day they emerged on to the Alpine pasturages, only to be caught in a furious blizzard of snow and hail, which necessitated camping for the night on a frozen peat bog. Next day a tent was carried higher up, as a base for reconnoitring excursions. The most important of the peaks on the south slope was ascended, and named Mount Höhnel, after the Austrian explorer. Five glaciers and eight lakes were discovered, as well as an interesting flora and fauna. A small shelter-tent was taken to near the end of the largest glacier, in readiness for an ascent of the central peak. A snow-slip during a severe storm in the night nearly buried this, and did cover all the food. The ascent had therefore to be attempted after a night's exposure to a severe storm, and without food. The main glacier, which was named after the late Prof. Carvell Lewis, was explored, and the *névé* field at its head crossed to the main south *arête*. After ascending this for some distance it became badly corniced, the risks of further progress were too serious to be encountered alone, and after reaching the height of a little over 17,000 feet it was necessary to return. In a subsequent attempt on the west *arête*, Dr. Gregory was caught in a severe snowstorm, which rendered the route followed in the ascent impassable, and might have entailed serious consequences. He was then recalled to attend to his men, many of whom were suffering severely from the cold and altitude, and an immediate descent to Leikipia was necessary; he had, however, achieved the five purposes for which he visited the mountain.

During the return to the coast much new ground was covered with some interesting topographical results; but except for securing a passage across Kikuyu, by curing the chief of toothache, this part of the journey presented little of general interest.

In conclusion, some of the scientific results of the expedition were summarised, though it was said to be too early to do this properly. Among the more interesting results was the discovery of the former greater extension of the glaciers of Mount

Kenia, as their moraines were found 5000 feet below their present level; this would have a great influence in the distribution of the Alpine flora in equatorial Africa. In spite of the numerous detailed studies of Kilima Njaro, no such evidence had been recorded from that mountain. The fish faunas are remarkably mixed, and show, as has long been surmised, that the distribution of the African rivers was once very different from the present. The geological results of the expedition suggest that at one time the Nile did not flow from the Nyanza, but rose in the mountains to the north; and the drainage of the lakes flowed away to the east and then to the north, past the site of Lake Rudolf to the Red Sea. Thus it was pointed out that the exploration of this part of Africa is of value not merely as supplying topographical information, but from its bearing on some important problems of geographical evolution.

THE GEOLOGY OF AUSTRALIA.[1]

IN the distant future the antiquity that this country can ever possess is the history of the occupation by its present holders; its aboriginal people have not furnished any evidence of a past history, insomuch, had it happened that they had become extinct a quarter of a century before their discovery, the only traces of prior occupation would have been in the form of stone knives and hatchets and flint spearheads. Interwoven with the history of the progress of discovery and occupation is that of the successive additions to our knowledge of its physical structure and its natural history. The records of botanical science and of geographical exploration have been brought up to a recent date; but the annals of the history of geological progress have not yet been consecutively placed on record. In the selection of a subject for my address I had experienced great difficulty in discriminating between personal interest and representative duty, and in choosing a "century of geological progress" for my theme I have sacrificed the former.

The labour involved in the preparation of this address has been very heavy, as I have read a hundred volumes to produce a very modest account; thus what I have done looks small when I recall the continuousness of the effort that accomplished it. The history of the progress of geology in Australia is intimately associated with that of its geographical discovery and of its advancement in scientific culture; it will constitute a chapter in the early history of modern Australia, and I venture to give some connected view of it, which, however bad it may be, is better than to have no view at all; moreover, there are associated with the subject personal histories which should be recorded whilst the knowledge of them is still within our memory. And although it is my special object to depict actual culminating results without any extended notice of the facts and events which may have led up to them, yet to a certain extent a knowledge of such facts and events is essential to their proper appreciation, and may be productive of increased interest.

Just prior to the close of the last century, the controversy between the Wernerian and Huttonian schools, or between Vulcanists and Neptunists, relating to the origin of the crust of the earth, was at its height. The Huttonian theory, which prevailed, recognises that the strata of the present land surfaces were formed out of the waste of pre-existing continents, and that the same forces are still active. The characteristic feature of Hutton's theory is the exclusion of all causes not recognised to belong to the present order of nature. With the opening of the present century a new school arose, which laid the foundation of modern geology. Three men were largely concerned in this achievement—Cuvier, Lamarck, and William Smith; the two former in France had all the powers which great talent, education, and station could give, whilst the last was an English land surveyor without culture or influence. George Cuvier laid the foundation of comparative osteology, recent and fossil; Lamarck that of invertebrate palæontology; whilst Smith established the fundamental principles of stratigraphical palæontology, viz. the superposition of stratified rocks and the succession of life in time.

The earliest geological observations relating to Australia antedate by only a few years the beginning of this century, so that the history of our progress in geology is concurrent with that of modern geology, and it affords grand illustrations of the methods of application of the laws as they were successively evolved in the European schools, to an area so distantly removed from that which gave them birth. Thus our history begins at a most fortuitous period. No prejudices or scholastic disputations have retarded our progress, for those who have aided in the work were disciples in the modern school of geology. And though, on a retrospective glance, we may hesitate to attach any high value to the labours of pioneer geologists, yet we should not forget that our horizon is so much vaster than theirs was, and to the extension of it they had lent their aid. And though it may be true that if the geological progress of the first half of this century were quite ignored, we would not probably suffer any great loss, as I believe that nearly all the areas explored at the earliest period have been re-examined in later times by men more carefully trained than was previously possible, nevertheless the gradual accumulation of data supplies us with a history, and makes us better acquainted with the causes that at certain times made that progress slow, or even retarded it. For the first three or four decades of this century our geological knowledge had been almost entirely the outcome of maritime surveys, whilst in later years it has been largely supplemented by inland exploration; thus, for a half-century or so the geological progress is part of the history of topographical discovery, which explains why our earlier geological information is inseparable from the achievements of such renowned geographers as Flinders, Baudin, King, Sturt, Mitchell, Stokes, Wilkes, Leichardt, Gregory, &c. The subsequent history of our geological progress commences with the establishment of systematic geological surveys in New South Wales and Victoria, which afterwards led to their extension to the other provincial areas. Almost simultaneously, universities were founded at Melbourne and Sydney; thus whilst the surveys dealt with geology more in its industrial applications, the universities upheld its value on purely scientific grounds. By these agencies a large interest was awakened in the science, and many in whom zeal had been latent were added to the ranks of geological investigators. Much of the knowledge gained in these various ways is expressed on the geological map of Australia, published by the Victorian Government in 1887. The several steps by which this map has been built up, I will endeavour to make known to you, and though my geological reminiscences do not extend far back, yet they embrace some of the most important discoveries made on this continent; at the same time I would wish to avoid the mistake of claiming too large an authority on account of my years.

Though the discovery of Australia may date back to the middle of the sixteenth century, yet it continued a *terra incognita*, at least from a scientific point of view, until Cook—the Columbus of the south—began in 1770 the present phase of scientific expeditions; and though geology reaped no gain, yet in botany was laid the foundation of a knowledge of that marvellous and peculiar flora of Australia through the labours of Banks and Solander, the companions of Cook.

Vancouver, who discovered King George Sound in 1791, describes the summit of Bald Head to be covered with a coral structure, amongst which are many sea-shells, and argued a modern date of elevation. However faulty the interpretation of the nature of the data may be, yet the deduction is sound, and that may be claimed as the first recorded geological observation for Australia, made 102½ years ago.

Coal was discovered in New South Wales in 1797, first to the south of Sydney, and in the same year on the banks of the River Hunter, at what is now Newcastle.

Flinders and Bass, jointly and separately, between the years 1797 and 1798, had explored the coast-line southward from Sydney, reaching as far west as Western Port, and embracing the circumnavigation of Tasmania. The more prominent rock phenomena were described. In 1801 Flinders was commissioned to complete the examination and survey of New Holland. The coast-line of Australia was traced with care as far as the tropics; Flinders paid much attention to physiographic features, whilst Brown collected rock specimens. The rock specimens collected on this survey were reported on by Dr. Filton in 1825, but beyond their mere enumeration and their agreement with those of the same denomination from other parts of the world, no attempt was made to chronologically arrange them; others collected by Brown, during his sojourn in New South Wales, were reported on by Dean Buckland in 1821, hereafter referred to.

Contemporaneously with the marine survey by Flinders was

[1] A part of the inaugural address delivered at Adelaide, on September 26, 1893, by Prof. Ralph Tate, the newly-elected President of the Australian Association for the Advancement of Science.

that by the French under Baudin. The scientific equipment was unrivalled in the annals of Australian exploration. To Depuch and Bailly were entrusted the mineralogical and geological researches. The former left the ship at Sydney to return to Europe, but he died at Mauritius, and his manuscripts, which he had taken with him, and were to serve for a geological history of New Holland, were irrecoverably lost. Peron was the senior zoologist, and the author of the narrative of the expedition. Peron's account of the physiography and geology of the places visited is not only graphic but rich in details; he closely investigated the nature and origin of the Æolian calciferous sandstones, and fully recognised their relationship to the blown-sand of the dunes. The entombed calcified shapes of branches and stems of trees were correctly recognised, though Vancouver and Flinders had erroneously considered them as coral reefs. He rightly referred the fundamental rocks of Kangaroo and King Islands to different kinds of primitive schists, and the superimposed fossiliferous limestone at the former place was correctly observed, though not attributed to any particular epoch. The occurrence of corals and marine shells of recent apearance at considerable elevations on the coast was justly regarded by him as demonstrating the "former abode of the sea" above the land, and very naturally suggested an inquiry as to the nature of the evolutions to which this change of situation is to be ascribed. Few geologists have been more in advance of the age in which they lived, or have suffered so long an undeserved oblivion, as Peron. After the termination of the survey by Flinders, through the loss of his ship, and subsequent detention by the French, in which France was the first to debase, as she was the first to promulgate, that principal axiom of international law, "Causa scientiarum, causa populorum" (the cause of science is the cause of the people), twelve years elapsed before England's attention was diverted from the battle-field to geographical discoveries in Australia by the appointment of Captain King to complete the coast surveys left unfinished by Flinders, which occupied him from 1818 to 1822. King could spare but little time to land, and, with few exceptions, merely traced the coast. The paucity of geological information is thus accounted for, and the few references are merely lithological. John Oxley, Surveyor-General, to whom we owe the earliest topographical map of New South Wales, took charge in 1817 of an expedition to ascertain the character of the western interior, a practicable route across the Blue Mountains having been opened in 1815. He traced the Lachlan down to longitude 144°, and completed the discovery of the Blue Mountains, which constitute the prominent physiographic feature of New South Wales. In 1818 he traced the Macquarie River to its junction with the Darling. In the volume of his narrative are brief references to the occurrences of different rocks, amongst which the more noteworthy are coal at Port Macquarie Harbour, coal indications at the head of the Macleay River, and limestone at Limestone Creek on the Lachlan, and at Wellington Valley on the Macquarie, "which is the first that has hitherto been discovered in Australia." The geological specimens which were collected during the two expeditions were reported on by Dean Buckland as affording indications of primitive rocks (granite, mica, slate, clay-slate, and serpentine), trap, and limestone (resembling the transition limestone of England), as also those gathered by Robert Brown on the Hunter River, which are described as coal and shale with plant impressions, and the author states that there is analogy between the coal formation of the Hunter River and that of England, whilst certain fossiliferous rocks from Hobart are nearly, if not quite, identical with those of the mountain limestone of England and Ireland. This is the first application of palæontology to the stratigraphical chronology of the Australian rocks, and a successful one, as the positions assigned by Buckland to the two formations are substantially those accepted by the local geologists of to-day. Scott (Rev. Archdeacon) refers to the strata of the Newcastle coalfield as the "coal formation," and to the limestone as resembling in the character of its organic remains the "mountain limestone" of England, and thus independently arrived at the same conclusions as Buckland.

Jesson, the naturalist to the French surveying ship, *La Coquille*, and author of the history of the voyage during the years 1822–25, describes the geological features about Port Jackson. His arrangement is a great advance on prior contributions, as it establishes a definite successional order of deposits, and for the first time, though foreshadowed by his countryman Bailly, the superposition of the Sydney sandstone on the coal measures, and of the coal measures on the granites, is recognised. Up to this date no described fossil had been referred to as occurring in Australian deposits, and it was not till 1828 that Alex. Brongniart described *Glossopteris browniana* and *Phyllotheca Australis* from the Newcastle coal measures.

Sturt, in 1829, on his passage down the Murray, arrived at Overland Corner, and noted the sudden change from cliffs of sand and clay to fossiliferous limestone, which continued uninterruptedly to Lake Alexandrina. Sturt referred examples of the fossil mollusca, echinoids, and polyzoa, to species of the Eocene of England, Paris, and Westphalia, and thus established by similarity of organic remains, an old tertiary formation in Australia.

Mitchell (Major, afterwards Sir Thomas), in 1832 penetrated north, and reached the River Darling. His western limit in 1835 was the junction of the rivers Bogan and Darling, and the southern, in 1836, was Portland Bay. The chief geological facts recorded by Mitchell are: (1) That the higher ground about the sources of the tributary of the Murrumbidgee is composed of granite, on the flanks of which rests a fossiliferous limestone "much resembling the carboniferous of Europe," and another limestone containing corals belonging to the genus Favosites, and crinoids; (2) in Victoria, north of the divided range, granites and syenites are signalled, and clay slate on the river Campaspe; (3) the lower part of the Glenelg River and the coast districts as far as Portland Bay are occupied with a fossiliferous tertiary formation, frequently interrupted by trap and vesicular lava; hills of lava often occur, and one at least, Mount Napier, is described as still exhibiting a perfect circular crater.

The palæontological collections, which were made during Mitchell's three expeditions, were deposited in the British Museum, and reported on by specialists. The results appended to Mitchell's work demonstrated the presence of representatives of the following life epochs: Carboniferous and Mesozoic. The collection included also a portion of the guard of a belemnite obtained near Mount Abundance. Its occurrence is noted on Mitchell's chart, though not referred to in the letter-press. This is the first secondary fossil recorded for Australia, though it was not till 1880 that it was brought to scientific notice.

Diprotodon Period.—The ossiferous caves of the Wellington Valley and at Buree were discovered by Mitchell in 1830, and an account of the survey of them was published in 1831. In 1835 more extended researches were undertaken, and the particulars respecting the animal remains then found were supplied by Owen (afterwards Sir Richard), who demonstrated that the existing marsupial fauna was preceded in the same area in later tertiary times by a similar one, differing specifically for the most part, and to some extent, generically; some of them presenting colossal forms in comparison with their largest modern representatives; such are Diprotodon and Nototherium. This early work of Owen's was only the commencement of those investigations which culminated in that monument of marvellous industry and talent, the "Fossil Mammals of Australia." Charles Darwin was naturalist to the surveying ship, the *Beagle*, on her second voyage, 1832–36. The *Beagle*, on her homeward passage, called at Sydney and King George's Sound, and the geological observations relating to those places are brief, and, to a large extent, had been anticipated by Mitchell in respect of the first, and by Peron as to the second, though in the latter connection Darwin corrected some of the erroneous observations recorded by Vancouver and Flinders. Lonsdale describes some Australian carboniferous polyzoa, and Sowerby some Spiriferidæ, and we have thus another instance of the early application of palæontology to the determination of the correlative age of stratified deposits.

Lieutenant Grey (now Sir George) was commissioned to explore the coastline between Prince Regent River and Swan River. In 1839 he was shipwrecked in Gantheaume Bay, and his party was forced to make an overland journey to Perth, in the course of which he discovered the Murchison and other rivers, and carboniferous rocks in the Victoria Range.

Commander Wickham was commissioned in 1837 to the *Beagle's* third voyage, but in consequence of his retirement in March, 1841, owing to ill-health, the command devolved on Captain Stokes, who is the author of the narrative of the six years' voyage. The objects of the survey did not permit of any connected observations of the geological structure of the islands or coast, and though the author disclaims any pretensions to be versed in geological science, yet some of his recorded observations have the merit of discoveries which have stood the test of critical investigation. The escarpment of the table-land of Arnheim Land is described as constituted of horizontally-bedded sandstone overlying slaty rock; a somewhat similar arrangement is noticed at Talc Head and Fort Hill, Port Darwin; the covering, fine-grained sandstone, the stratigraphical position of which was first observed by Stokes, has lately acquired considerable importance by the discovery of Radiolarians within its mass.

Strzelecki (Count).—To this highly accomplished man of science we are greatly indebted for arduous and gratuitous researches and labours in the field of Australian geology, the outcome of five years' travel, commencing from his traverse of Gippsland in 1840, and embracing the survey of 7,000 miles. The rocks of New South Wales he arranges in an ascending successional series, and in this first attempt to construct a table of the stratified deposits of New South Wales he laid the foundation of stratigraphical geology in Australia. Strzelecki's volume is accompanied by a map in which the areas occupied by each epoch are indicated by colours, and is the first attempt at geological mapping in Australia.

Leichardt (Dr. Ludwig).—In 1844 this lamented traveller started on his adventurous journey from Moreton Bay to Port Essington, a distance of 3000 miles. The narrative of Dr. Leichardt contains as much botany as geology. The accompanying maps and illustrations supply important information respecting the physiographic and geologic features. Necessity compelled him to abandon one portion after another of his collections, so that the opportunity of determining the age of the various deposits encountered, from the nature of their fossil contents, was lost. This is much to be regretted, because for long years this line of country was geologically known only through Leichardt's memoranda, which still contain for some portions the only information extant.

Dana (Prof. James D.) was naturalist to the United States exploring expedition during the years 1838–42, under the command of Charles Wilkes. Sydney was visited in 1839–40, but as the geology of the expedition was not published till 1849, Dana's observations were to some extent anticipated. Nevertheless, the credit must remain to Dana of having laid the foundation of the classification of the great carboniferous development in New South Wales, both in respect of its palæontology and stratigraphy.

Sturt (Captain Charles), in 1844, under the authority of the Imperial Government, pushed into the central parts of Australia. From the River Darling, at what is now Menindie, he reached the Barrier and Grey Ranges, and became entangled in the delta-like ramifications of the River Cooper; thence he penetrated in a north-west direction into the sand-dune country to the north-east of Lake Eyre, and thus missed the object of his ardent search. Sturt describes the general structure of the Barrier Range as of slates, gneiss, and other metamorphic rocks, and notes the prevalence of iron ores. In one case he describes what is evidently the ironstone outcrop of a massive mineral lode, and though I cannot identify the locality, yet it is not at all improbable that one of the silver lodes of the Barrier (if not Broken Hill itself) is here referred to; in the same connection that prominent landmark, Piesse's Knob, is indicated. The most noteworthy observations recorded by Sturt are those relating to the physical character of the interior of Australia, which will be considered hereafter. A tribute is due to Sturt's scientific merit and sagacity, and I would add my mite to the general testimony of admiration for that learned traveller; he stands pre-eminent among land explorers for the accuracy of his observations—evincing the most patient and thoughtful investigation—for the great power of generalisation which throws a charm over all his narratives, and for his highly philosophical deductions. Sturt never received that honour in his lifetime which was his due; and much of his geological work and speculations have either been overlooked or ignored, because it was thought, by reason that geology then was not in a very advanced state, he was not a very experienced geologist. In his work, "A Sketch of the Physical Structure of Australia" (1850), the author gives a connected outline of the geology of Australia, so far as it was known to him. The great merit of this attempt to exhibit approximately the principal features of this continent is that of piecing together the isolated observations of previous authors into a connected outline, which, because of his personal knowledge of considerable portions of the coastline of Australia, he was, of all others, the best able to do successfully, The result is a general but distinct notion of the geological structure of Australia, which is further illustrated by a geologically-coloured map, the first on so broad a survey. The author added nothing to our previous knowledge, but systematised what was known, and the speculations and generalisations which he ventured have, for the most part, proved correct. Some of the most valuable contributions of later authors will be found to have been foreshadowed, or even clearly noted, by Jukes, whilst some actual discoveries were anticipated by him.

The last of the maritime surveys under Imperial direction which concerned Australia was that conducted by Captain Owen Stanley, of H.M.S. *Rattlesnake;* it is also noteworthy from the high scientific attainments of its officers. The commander, who was the only son of Dean Stanley, an eminent ornithologist, took a keen interest in natural history; he died soon after the final return of the ship to Sydney, from a severe illness, contracted during the last cruise, but after the successful accomplishment of the chief object of his mission. The assistant-surgeon was Thomas H. Huxley, a name familiar to all, who achieved fame at this early period of his career by the zoological researches made during the voyage.

A. C. Gregory.—The discouraging character of the interior of Australia, as made known by Sturt, and the utter disappearance of Leichardt's expedition of 1848, checked the progress of exploration for a few years; but in 1855 a successful effort was made to penetrate the interior from the north-west by the North Australian expedition, which was fitted out by the Imperial Government, and was the last of the series. The expedition was placed under the leadership of Mr. A. C. Gregory, who was accompanied by Dr. (now Baron Sir F. von) Mueller as botanist. The Victoria River was ascended to its source, and the country to the south of the Dividing Range was explored beyond the northern limits of the great interior desert. The physiographic features of the Lower Victoria had been made known by the descriptions of Stokes; the region about the Upper Victoria was found to consist chiefly of extensive valleys of good soil, well grassed, and of more arid sandstone table-land, varied with outcrops of basalt, constituting rich grassy downs. The table-land rises abruptly from the coastal tracts. By removal of the upper strata deep gorges 600 feet in height are formed, which open out into large valleys or plains. Mr. Gregory struck across from the Lower Victoria to the head of Roper River, and thence followed the base of the table-land from which he had descended, passing near the sources of the rivers discharging into the Gulf of Carpentaria. From the Albert River to Brisbane he followed Leichardt's route of 1844. This extraordinary achievement is second to none in point of interest of unknown country traversed, and of the scientific results gained, a vast void in the geological map was filled in. Since Gregory's expedition the interior of Australia has been traversed in various directions; and with such efforts are honourably associated the names of Stuart, Burke and Wills, Warburton, Giles, J. Forrest, &c., but the geological gain has been of a purely local importance. I may therefore be pardoned if I make exception by the mention of the expedition recently fitted out by Sir Thomas Elder. The object—to fill up the blank spaces in the topographical and geological maps of Australia—was ambitious, and the scientific equipment of the expedition gave hope that permanent results would be gained, but its premature disbandment has indefinitely protracted the realisation of this cherished consummation. So far as the area traversed is concerned, a very great deal was accomplished. It was a failure simply by reason of the limitation of the original scheme. In geology nothing new has been brought to light, though certainty has replaced previous guesswork or speculation. Nevertheless, such problems as the exact relation of the fossiliferous Silurian to those of older date, the stratigraphy and fossils of the marine Cretaceous, and its relation to the supra-cretaceous rocks, still await solution. The geologist to the expedition has done his work so conscientiously and thoroughly, that the poverty of his report is to be ascribed to nature's deficiency. In other departments of natural history our expectations have been satisfactorily realised. May we hope that the Australian Macænas of our time will crown his efforts to unfold some of the mysteries of our dry interior by directing a systematic exploration of some well-defined area, such as the oasis of the MacDonnell Range.

The year of 1851 marks an epoch in the history of Australia, because in that year the rich goldfield of Ophir was discovered. Gold was scientifically discovered by Strzelecki, in 1839, and by

Clarke in 1841, though its existence would appear to have been known as early as 1823. In 1844, without being aware of these discoveries, Sir Roderick Murchison pointed out the similarity of the rock structure of the eastern cordillera of Australia to that of the Ural Mountains, and predicted the occurrence of gold. Subsequent events afforded a proof that geology, like the more exact sciences, is capable of advancing philosophical inductions to very important results. But the precious metal was not commercially discovered, so to speak, till 1851, by Hargreaves, who had spent some of his earlier years as a stock-raiser in Eastern Australia; in 1849 he was gold-mining in California, and his experiences there gained convinced him of the similarity in structure of the auriferous rocks of California and certain districts in New South Wales. He revisited New South Wales early in 1851, to put to the test his geological instinct and the accuracy of his observations; in this he succeeded, and ultimately, under Government direction, the gold-field of Ophir in the district of Bathurst was declared open. He was awarded £10,000 for his discovery, and in 1876 a pension was granted him. He died in 1891, at the age of 75 years. The practical discovery of gold proved a source of an enormous amount of wealth to New South Wales, and was soon followed in the same year by the discovery of much richer goldfields in Victoria, which had just then been separated into an independent colony, and thus added a powerful factor to the economic and scientific advancement of the continent. The consequent stimulus to a higher intellectual culture resulted in the foundation of the Universities of Sydney and Melbourne, and the establishment of systematically organised geological surveys. By the concurrence of the memorable events just alluded to, the history of geological progress enters a new period. Up to 1854 our exact knowledge of the sedimentary deposits, as derived from the organic remains, was confined to the Carboniferous, to a late Tertiary (represented by the Diprotodon period), and a more recent Æolian formation; no distinct identification to prove the existence of Upper Silurian, Devonian, or Eocene had been forthcoming, though it was implied, whilst the only evidence of a Mesozoic epoch was a single imperfect example of a Belemnite. Restricted means of communication in a vast extent of country was the main cause which retarded advancement in geological investigation; with increasing population this barrier is gradually being removed. Expansion of our pastoral occupation, and the opening out of new trade routes bring new fields within the horizon of geological vision. It is, therefore, not a matter for surprise that in the next decade great and rapid advances were made in establishing a comparison on palæontological grounds with corresponding geological systems of Europe. The history of geological progress in the second half-century is mainly that of the geological surveys, and the chronological treatment of my subject must be abandoned at this stage.

It is a general impression that Australia is a very old continent; undoubtedly it is, because it presents an equal range of the geological record as other continental masses. But this impression is based on illogical deduction, derived solely from the fact that certain characteristic types of the Jurassic fauna of the northern hemisphere still linger in the Australian area, such as Trigonia, Ceratodus, and Marsupials among animals, Cycads and certain Conifers among plants. But the physiographic aspects of Australia have not always been absolutely continental. Since Upper Devonian times there have always been land-surfaces, at any rate in Eastern Australia, where partial interruption to an absolute continuity (and the area locally affected is not relatively great) was frequent during the deposition of the Carboniferous series, which is, however, in a large measure littoral. It may safely be asserted that Australia, certainly so far back as the deposition of the extensive marine Cretaceous occupying the low level tracts of the interior, preserved the aspect of a vast archipelago. At the close of that epoch the various insular masses became welded together, so that the antiquity of Australia as a whole is only post-Cretaceous. In early Eocene or late Cretaceous times, the flora was of a cosmopolitan type, consisting of an admixture of generic forms, some of which are now proper to the temperate and sub-temperate parts of the northern hemisphere, such as oaks, birch, alder, &c., and others exclusively Australian, such as eucalypti, banksias, Araucarias, &c. The differentiation of the Australian flora has therefore been brought about during the post-Eocene times. The antiquity of Australia, as inferred from its almost exclusive marsupial types, is erroneous, because there is every reason to doubt the correctness of the statement thereby implied that marsupials originated in Australia. Despite the recurrences of land surfaces from late Palæozoic times to the present day—and it is not improbable that some of them may have been permanent throughout, or for a greater part of that long interval—yet no marsupials as old as those of Europe and North America have yet been found; neither its coaly strata nor its ancient lake basins have yielded any of the higher types of fluviatile or terrestrial vertebrates. Indeed, the only instance of a fossil representative of the Marsupialia older than Pliocene in the Australian area is that of a diprotodontoid in the Eocene beds at Table Cape, Tasmania; whereas we must look for a polyprotodontoid as the early ancestor of the class. Recent researches point to South America as the area from which the Australian marsupial fauna has probably been derived, which possesses in the Eocene marsupial fauna close alliances with certain existing polyprotodontoid types in Australia.

A DYNAMICAL THEORY OF THE ELECTRIC AND LUMINIFEROUS MEDIUM.[1]

II.

THE next stage in this mode of elucidation of electrical phenomena is to suppose, once the current is started in our non-dissipative circuit, that both the condensers are instantaneously removed, and replaced by continuity of the wire. We are now left with a current circulating round a complete perfectly conducting channel, which in the absence of viscous forces will flow round permanently. The expression for the kinetic energy in the field is easily transformed from a volume integral of the magnetic force, which is represented by the velocity of the medium $\frac{d}{dt}(\xi, \eta, \zeta)$, to an integral involving the current $\frac{d}{dt}(f, g, h)$, which is in the present case a line integral round the electric circuit. The result is Franz Neumann's celebrated formula for the electromagnetic energy of a linear electric current,

$$T = \tfrac{1}{2}\iota^2 \int\int r^{-1} \cos \epsilon \, ds \, ds ;$$

or we may take the case of several linear circuits in the field, and obtain the formula

$$T = \tfrac{1}{2}\Sigma\iota^2 \int\int r^{-1} \cos \epsilon \, ds \, ds + \Sigma \iota_1 \iota_2 \int\int r^{-1} \cos \epsilon \, ds_1 \, ds_2,$$

which is sufficiently general to cover the whole ground of electro-dynamics.

Our result is in fact that a linear current is a vortex ring in the fluid æther, that electric current is represented by vorticity in the medium, and magnetic force by the velocity of the medium. The current being carried by a perfect conductor, the corresponding vortex is (as yet) without a core, *i.e.* it circulates round a vacuous space. The strength of a vortex ring is, however, permanently constant; therefore, owing to the mechanical connections and continuity of the medium, a current flowing round a complete perfectly conducting circuit would be unaffected in value by electric forces induced in the circuit, and would remain constant throughout all time. Ordinary electric currents must therefore be held to flow in incomplete conducting circuits, and to be completed either by convection across an electrolyte, or by electric displacement or discharge across the intervals between the molecules, after the manner of the illustration given above.

Now we are here driven upon Ampère's theory of magnetism. Each vortex-atom in the medium is a permanent non-dissipative electric current of this kind, and we are in a position to appreciate the importance which Faraday attached to his discovery that all matter is magnetic. Indeed, on consideration, no other view than this seems tenable; for we can hardly suppose that so prominent a quality of iron as its magnetism completely disappears above the temperature of recalescence, to reappear again immediately the iron comes below that temperature; much the more reasonable view is that the molecular rearrangement that takes place at that temperature simply masks the permanent magnetic quality. In all substances other than the

[1] A paper read before the Royal Society on December 7, 1893, by Dr. Joseph Larmor, F.R.S., Fellow of St. John's College, Cambridge. (Continued from p. 262.)

magnetic metals, the vortex atoms pair into molecules and molecular aggregates in such way as to a large extent cancel each other's magnetic fields; why in iron at ordinary temperatures the molecular aggregates form so striking an exception to the general rule is for some reason peculiar to the substance, which, considering the complex character of molecular aggregation in solids, need not excite surprise.

We have now to consider the cause of the pairing together of atoms into molecules. It cannot be on account of the magnetic, *i.e.* hydrodynamical, forces they exert on one another, for two electric currents would then come together so as always to reinforce each other's magnetic action, and all substances would be strongly magnetic. The ionic electric charge, which the phenomena of electrolysis show to exist on the atom, supplies the attracting agency. Furthermore, the law of attraction between these charges is that of the inverse square of the distance, and between the atomic currents is that of the inverse fourth power; so that, as in the equilibrium state of the molecule these forces are of the same order of intensity and counteract each other, the first force must have much the longer range, and the energy of chemical combination must therefore be very largely electrostatic, due to the attraction of the ions, as von Helmholtz has clearly made out from the phenomena of electrolysis and electrolytic polarisation.

But in this discussion of the phenomena of chemical combination of atoms we have been anticipating somewhat. All our conclusions, hitherto, relate to the æther, and are therefore about electromotive forces. We have not yet made out why two sets of molecular aggregates, such as constitute material bodies, should attract or repel each other when they are charged, or when electric currents circulate in them; we have, in other words, now to explain the electrostatic and electrodynamic forces which act between conductors.

Consider two charged conductors in the field; for simplicity, let their conducting quality be perfect as regards the very slow displacements of them which are contemplated in this argument. The charges will then always reside on their surfaces, and the state of the electric field will, at each instant, be one of equilibrium. The magnitude of the charge on either conductor cannot alter by any action short of a rupture in the elastic quality in the æther; but the result of movement of the conductors is to cause a rearrangement of the charge on each conductor, and of the electric displacement (f, g, h) in the field. Now the electric energy W of the system is altered by the movement of the conductors, and no viscous forces are in action; therefore the energy that is lost to the electric field must have been somehow spent in doing mechanical work on the conductors; the loss of potential energy of the electric field reappears as a gain of potential energy of the conductors. We have to consider how this transformation is brought about. The movement of the conductors involves, while it lasts, a very intense flow of ideal electric displacement along their surfaces, and also a change of actual displacement of ordinary intensity throughout the dielectric. The intense surface flow is in close proximity with the electric flows round the vortex atoms which lie at the surface; their interaction produces a very intense elastic disturbance in the medium, close at the surface of the conductor, which is distributed by radiation through the dielectric as fast as it is produced, the elastic condition of the dielectric, on account of its extreme rapidity of propagation of disturbances compared with its finite extent, being always extremely nearly one of equilibrium. It is, I believe, the reaction on the conductor of these wavelets which are continually shooting out from its surface, carrying energy into the dielectric, that constitutes the mechanical forcive acting on it. But we can go further than this; the locality of this transformation of energy, so far at any rate as regards the material forcive, is the surface of the conductor; and the gain of mechanical energy by the conductor is therefore correctly located as an absorption of energy at its surface; therefore the forcive acting on the conductor is correctly determined as a surface traction, and not a bodily forcive throughout its volume. One mode of representing the distribution of this surface traction, which, as we know, gives the correct amount of work for every possible kind of virtual displacement of the surface, is to consider it in the ordinary electrostatic manner as a normal traction due to the action of the electric force on the electric density at the surface; we conclude that this distribution of traction is the actual one. To recapitulate: if the dielectric did not transmit disturbance so rapidly, the result of the commotion at the surface produced by the motion of the conductor would be to continually start wavelets which would travel into the dielectric, carrying energy with them. But the very great velocity of propagation effectually prevents the elastic quality of the medium from getting hold; no sensible wave is produced and no flow of energy occurs into the dielectric. The distribution of pressure in the medium which would be the accompaniment of the wave motion still persists, though it now does no work; it is this pressure of the medium against the conductor that is the cause of the mechanical forcive.

The matter is precisely illustrated by the fundamental *aperçu* of Sir George Stokes with regard to the communication of vibrations to the air or other gas. The rapid vibrations of a tuning-fork are communicated as sound waves, but much less completely to a mobile medium like hydrogen than to air. The slow vibrations of a pendulum are not communicated as sound waves at all; the vibrating body cannot get a hold on the elasticity of the medium, which retreats before it, preserving the equilibrium condition appropriate to the configuration at the instant; there is a pressure between them, but this is instantaneously equalised throughout the medium as it is produced, without leading to any flow of vibrational energy.

Now let us formally consider the dynamical system consisting of the dielectric media alone, and having a boundary just inside the surface of each conductor; and let us contemplate motions of the conductors so slow that the medium is always indefinitely near the state of internal equilibrium or steady motion, that is conditioned at each instant by the position and motion of the boundaries. The kinetic energy T of the medium is the electrodynamic energy of the currents, as given by Neumann's formula; and the potential energy W is the energy of the electrostatic distribution corresponding to the conformation at the instant; in addition to these energies we shall have to take into account surface tractions exerted by the enclosed conductors on the medium, at its boundaries aforesaid. The form of the general dynamical variational equation that is suitable to this problem is, for currents in incomplete circuits, and therefore acyclic motions,

$$\delta \int (\mathrm{T} - \mathrm{W})\, dt + \int dt \int \delta w \, d\mathrm{S} = 0,$$

where $\delta w \, d\mathrm{S}$ represents the work done by the tractions acting on the element $d\mathrm{S}$ of the boundary, in the virtual displacement contemplated. If there are electromotive sources in certain circuits of the system, which are considered to introduce energy into it from outside itself, the right-hand side of this equation must also contain an expression for the work done by them in the virtual displacement contemplated of the electric coordinates. Now this variational equation can be expressed in terms of any generalised coordinates whatever, that are sufficient to determine the configuration in accordance with what we know of its properties. If we suppose such a mode of expression adopted, then, on conducting the variation in the usual manner and equating the coefficients of each arbitrary variation of a coordinate, we obtain the formulæ

$$\Phi = \frac{d}{dt}\frac{d\mathrm{T}}{d\dot\phi} - \frac{d\mathrm{T}}{d\phi} + \frac{d\mathrm{W}}{d\phi},$$

$$\mathrm{E} = \frac{d}{dt}\frac{d\mathrm{T}}{d\dot e}.$$

In these equations Φ is a component of the mechanical forcive exerted on our dielectric system by the conductors, as specified by the rule that the work done by it in a displacement of the system represented by $\delta\phi$, a variation of a single coordinate, is $\Phi\delta\phi$: the corresponding component of the forcive exerted by the dielectric system on the conductor is of course $-\Phi$. Also E is the electromotive force which acts from outside the system in a circuit in which the electric displacement is e, so that the current in it is $\dot e$; the electromotive force induced in this circuit by the dielectric system is $-$E.

These equations involve the whole of the phenomena of ordinary electrodynamic actions, whether ponderomotive or electromotive, whether the conductors are fixed or in motion through the medium: in fact, in the latter respect no distinction appears between the cases. They will be completed presently by taking account of the dissipation which occurs in ordinary conductors.

These equations also involve the expressions for the electrostatic ponderomotive forces, the genesis of which we have already attempted to trace in detail. The generalised component, corresponding to the coordinate ϕ, of the electrostatic traction of the conductors on the dielectric system, is $dW/d\phi$; therefore the component of the traction, somehow produced, of the dielectric system on the conductors is $-dW/d\phi$.

The stress *in the æther* between two electrified bodies consists of a tangential traction on each element of area, equal in magnitude to the tangential component of the electric force at that place and at right angles to its direction. The stress in the *material* of the dielectric is such as is produced in the ordinary manner by the surface tractions exerted on the material by the conductors that are imbedded in it. The stress in the dielectric of Faraday and Maxwell has no real existence; it is, in fact, such a stress as would be felt by the surface of a conductor used to explore the field, when the conductor is so formed and placed as not to disturb the electric force in the dielectric. The magnetic stress of Maxwell is simply a mathematical mode of expression of the kinetic reaction of the medium.

The transfer of a charged body across the field with velocity not large compared with the velocity of electric propagation carries with it the whole system of electric displacement belonging to the body, and therefore produces while it lasts a system of displacement currents in the medium, of which the circuits are completed by the actual flow of charge along the lines of motion of the different charged elements of the body.

According to the present theory of electrification, a discharge of electricity from one conductor to another can only occur by the breaking down of the elasticity of the dielectric æther along some channel connecting them; and a similar rupture is required to explain the transfer of an atomic charge to the electrode in the phenomenon of electrolysis. We can conceive the polarisation increasing by the accumulation of dissociated ions at the two electrodes of a voltameter, until the stress in the portion of the medium between the ions and the conducting plate breaks down, and a path of discharge is opened from some ion to the plate. While this ion retained its charge, it repelled its neighbours; but now electric attraction will ensue, and the one that gets into chemical contact with it first will be paired with it by the chemical forces; while if the conducting path to the electrode remains open until this union is complete, the ion will receive an opposite atomic charge from the electrode, which very conceivably may have to be also of equal amount, in order to equalise the potentials of the molecule and the plate. This is on the hypothesis that the distance between the two ions of a molecule is very small compared with the distance between two neighbouring molecules. A view of this kind, if thoroughly established, would lead to the ultimate averaging of atomic changes of all atoms that have been in combination with each other, even if those charges had been originally of different magnitudes. The assignment of free electric charges to vortex atoms tends markedly in the direction of instability; though instability under certain circumstances is essential to electric discharge, yet it must not be allowed to become dominant.

The presence of vortex atoms, forming faults so to speak in the æther, will clearly diminish its effective rotational elasticity; and thus it is to be expected that the specific inductive capacities of material dielectrics should be greater than the inductive capacity of a vacuum. The readiness with which electrolytic media break down under electric stress may be connected with the extremely high values of their inductive capacities, indicating very great yielding to even a small electric force.

In all that has been hitherto said we have kept clear of the complication of viscous forces; but in order to extend our account to the phenomena of opacity in the theory of radiation and of electric currents in ordinary conductors, it is necessary to introduce such forces and make what we can of them on general principles. It is shown that the introduction of the dissipation function into dynamics by Lord Rayleigh enables us to amend the statement of the fundamental dynamical principle, the law of Least Action, so as to include in it the very extensive class of viscous forces which are proportional to absolute or relative velocities of parts of the system. This class is the more important because it is the only one that will allow a simple wave to be propagated through a medium with period independent of its amplitude; if the viscous forces that act in light propagation were not of this kind, then on passing a beam of homogeneous light through a metallic film it should emerge as a mixture of lights of different colours. The viscous forces being thus proved by the phenomena of radiation to be derived from a dissipation function, it is natural to extend the same conclusion to the elastic motions of slower periods than radiations, which constitute ordinary electric disturbances. We thus arrive, by way of an optical path, at Joule's law of dissipation of electric energy, and Ohm's linear law of electric conduction, and the whole theory of the electrodynamics of currents flowing in ordinary conductors; though the presumption is that the coefficients which apply to motions of long period are not the same as those which apply to very rapid oscillations, the characters of the matter-vibrations that are comparable in the two cases being quite different. If it is assumed that the form of the dissipation function is the same for high frequencies as for low ones, we obtain the ordinary theory of metallic reflexion, which differs from the theory of reflexion at a transparent medium simply by taking the refractive index to be a complex quantity, as was done originally by Cauchy, and later for the most general case by MacCullagh. And, in fact, we could not make a more general supposition than this for the case of isotropic media; while for crystalline media the utmost generality would arise merely from assuming the principal axes of the dissipation function to be different from those of the rotational elasticity, a hypothesis which is not likely to be required.

The considerations which have here been explained amount to an attempt to extend the regions of contact between three ultimate theories which have all been already widely developed, but in such a way as not to have much connection with one another. These theories are Maxwell's theory of electric phenomena, including Ampère's theory of magnetism and involving an electric theory of light, Lord Kelvin's vortex-atom theory of matter, and the purely dynamical theories of light and radiation that have been proposed by Green, MacCullagh, and other authors. It is hoped that a sufficient basis of connection between them has been made out, to justify a restatement of the whole theory of the kind here attempted, notwithstanding such errors or misconceptions on points of detail as will unavoidably be involved in it.

Lord Kelvin has proposed a gyrostatic adynamic medium which forms an exact representation of a rotationally elastic medium such as has been here described.[1] If the spinning bodies are imbedded in the æther so as to partake fully in its motion, the rotational forcive due to them is proportional jointly to the angular momentum of a gyrostat and the angular velocity of the element of the medium, in accordance with what is stated above. But if we consider the rotators to be free gyrostats of the Foucault type, mounted on gymbals of which the outer frame is carried by the medium, there will also come into play a steady rotatory forcive, proportional jointly to the square of the angular momentum of the gyrostat and to the absolute angular displacement of the medium. An ideal gyrostatic cell has been imagined by Lord Kelvin in which the coexistence of pairs of gyrostats spinning on parallel axles in opposite directions cancels the first of these forcives, thus leaving only a static forcive of a purely elastic rotational type. The conception of an æther which is sketched by him on this basis,[2] is essentially the same as the one we have here employed, with the exception that the elemental angular velocity of the medium is taken to represent magnetic force, and in consequence the medium fails to give an account of electric force and its static and kinetic manifestations. A gyrostatic cell of this kind has internal freedom, and therefore free vibration periods of its own; it is necessary to imagine that these periods are very small compared with the periods of the light waves transmitted through the medium, in order to avoid partial absorption. The propagation of waves in this æther, having periods of the same order as the periods of these free vibrations, would of course be a phenomenon of an altogether different kind, involving diffusion through the medium of energy of disturbed motion of the gyrostats within the cells.

The electric interpretation of MacCullagh's optical equations, which forms the basis of this paper, was first stated by Prof. G. F. Fitzgerald (*Phil. Trans.*, 1880). An electric development of Lord Kelvin's rotational æther has been essayed by Mr. Heaviside, who found it to be unworkable as regards conduction-current, and not sufficiently comprehensive (*Phil. Trans.*, 1892, § 16; "Electrical Papers," vol. ii. p. 543). A method of representing the phenomena of the electric field by the motion of

[1] Lord Kelvin (Sir W. Thomson), *Comptes Rendus*, September 16, 1889; "Collected Papers," vol. iii., 1890, p. 467.
[2] Lord Kelvin (Sir W. Thomson), "Collected Papers," vol. iii., 1890, pp. 436-472.

tubes of electric displacement has been developed by Prof. J. J. Thomson, who draws attention to their strong analogies to tubes of vortex motion ("Recent Researches . . . ," 1893, p. 52).

Prof. Oliver Lodge has kindly looked for an effect of a magnetic field on the velocity of light, but has not been able to detect any, though the means he employed were extremely searching; the inference would follow, on this theory, that the motion in a magnetic field is very slow, and the density of the medium correspondingly great.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The lectures announced by the various departments of Natural Science are for the most part a continuation of the courses given during the last term. In all, thirty-two separate courses of lectures are announced, nine in Physics, eight in Chemistry, two in Geology, four in Animal Morphology, four in Physiology, two in Botany, and three in Anthropology. The Hope Professor of Zoology, Mr. E. B. Poulton, is absent from Oxford this term, and the charge of the collection devolves on his assistant. In addition, Mr. Hatchett Jackson has consented to give any information that may be required respecting the Hope Collections.

The next examination for admission to a Radcliffe Travelling Fellowship will be held on March 1. Candidates are required to have obtained a first class in one of the honour schools, or to have gained an open University prize or scholarship, and to undertake a course of medical study with the view of proceeding to a medical degree.

CAMBRIDGE.—Mr. J. E. Purvis, of St. John's College, has been appointed Assistant to the Professor of Chemistry in the room of Mr. H. Robinson, who died on January 4. Mr. Robinson had held his office for sixteen years, and had, with Prof. Liveing and independently, conducted a number of important researches. Those on lauthanum and didymium, and on certain points in bacteriological chemistry deserved greater notice than they received. Mr. Robinson's work in agricultural chemistry, in which he was an expert, will be carried on by Mr. T. B. Wood, of Caius College. Dr. Lorrain-Smith and Dr. Wesbrook, John Lucas Walker Students in Pathology, will this term conduct, in Prof. Roy's laboratory, a new course of instruction in pathological chemistry. The lectures will be given on Mondays and Saturdays at noon, beginning on January 20. Mr. H. Yule Oldham, University Lecturer in Geography, will resume his lectures in physical geography on Thursdays at noon in the lecture theatre of the chemical laboratory; and will give informal instruction and assistance to students of geography in King's College on the same days at six o'clock. The election to the £100 studentship, offered by the Council of the Royal Geographical Society for members of the University attending the lectures, will be held on March 12.

AN influential deputation, representing the University Colleges of Wales, waited upon the Chancellor of the Exchequer on Friday last, to ask for an annual grant of £3,000 to the new Welsh University. In reply, Sir W. Harcourt said he would request the Government to grant the request for the present year, but he could promise nothing for the future.

SCIENTIFIC SERIALS.

Bulletin de l'Académie Royale de Belgique.—Stas's determinations of atomic weights, by E. Vogel. In spite of Stas's conclusion that the atomic weights of the elements have no common measure, Prout's hypothesis has recently been regaining ground. Hinrichs's experiments have thrown doubt upon Stas's atomic weight determinations; and the suppositions made by Stas himself place it beyond doubt that all his atomic weights without exception are inaccurate. The cause of the great discrepancies in the values found by Stas himself lies in the variation of the weights of the substances taken. When to a solution of an alkaline chloride is added nitrate of silver to slight excess, a precipitate will be formed on adding more chloride. But experiment shows that a precipitate is also formed on adding more nitrate, up to a certain limit which Mulder termed the limit of silver, as distinguished from the limit of salt for the addition of the chloride. The author shows that the true atomic weight cannot be derived from the mean between these two limits, and proves from Stas's own data that they may be equally well interpreted for entire as for fractional multiples of the atomic weight of hydrogen.—Chronometric determinations relating to the regeneration of nerves, by C. Vanlair. The experiments, conducted by the physiological method, were made upon a motor nerve, the facial, a nerve whose simultaneous bilateral section is inconsistent with life, the pneumogastric, and a mixed sensory nerve, the sciatic. The right facial nerve of an adult rabbit, the two inferior branches of which were cut as they emerged from the parotid, required eight months for their regeneration. The right pneumogastric of an adult dog was cut in June 1889, and the left, one year afterwards. In August, 1891, the right nerve was cut again, but, after some initial troubles, the dog's health remained perfect throughout. Since the simultaneous section of the two branches is invariably fatal, it follows that during the time intervening between the sections the branch last cut must have reunited. This gives a velocity of reproduction of 3 c.m. per month, or 1. mm. per day. In the dog, and doubtless also in man, nervous regeneration, undisturbed by any accidental obstacle, takes place with an almost perfect chronological regularity. The average time necessary for initial proliferation is about forty days. For a section of about 1 c.m. length, the development of the new fibres takes place at a rate of 0·25 mm per day. The speed is greater at 2 c.m. but decreases again for greater lengths in proportion to such lengths.

Mémoires de la Société d'Anthropologie de Paris, Tome i. (3e Série) 1er Fascicule.—A new series of the memoirs of the Anthropological Society of Paris commences with this number, and opportunity has been taken to introduce a few modifications into the manner of their publication. In future each memoir will be paged separately, and will be sold at the price of three centimes a page. This part contains an essay by M. A. Dumont, on the birth rate in the canton of Beaumont-Hague. The author says that France is menaced by five great perils: (1) Foreign invasion; (2) advance of plutocracy; (3) increase of clericalism; (4) lowering of the birth-rate; (5) increase of rural emigration. With regard to these last two dangers, it is of the utmost importance to determine their extent, their causes, and their remedies. The tables given by the author show that in almost all the villages in the canton of Beaumont-Hague the population has steadily diminished within the last sixty years, in some cases as much as fifty per cent., and this large diminution of population appears to result from the excess of the death rate over the birth rate. In one parish only has the population increased, and this has been due to the fact that a number of those employed in the Government works at Cherbourg have taken up their residence here within the last few years since 1886. M. Dumont discusses at length the causes of the very low birth rate throughout the canton, and comes to the conclusion that it is closely connected with the emigration of the more well-to-do inhabitants, and that increase in population is in inverse proportion to individual effort for personal advancement.

SOCIETIES AND ACADEMIES.

Royal Society, Dec. 14, 1893.—"Sugar as a Food in the Production of Muscular Work." By Dr. Vaughan Harley.

In the above paper the author first gave the chemical reasons that led him to believe that sugar was the principal factor in the production of muscular energy.

He then went on to prove that it could be experimentally demonstrated that the addition of large quantities of sugar to the diet caused an increased capability of doing muscular work.

By means of the ergograph it was possible to estimate the amount of work accomplished under various circumstances by the middle finger of each hand, weights of 3 and 4 kilogrammes being raised. The total height to which the weight was lifted, being multiplied by the weight used, expressed in kilogramme metres the amount of work accomplished.

The first step was to ascertain the value of sugar when taken alone in the production of muscular work. During a twenty-four hours' fast, on one day, water alone was drunk; on another, 500 grammes of sugar was taken in an equal quantity of water. It was thus found that the sugar not only prolonged the time before fatigue occurred, but caused an increase of 61 to 76 per cent. in the muscular work done.

In the next place, the effect of sugar added to the meals was investigated.

The muscle energy producing effect of sugar was found to be so great that 200 grammes added to a small meal increased the total amount of work done from 6 to 39 per cent.

Sugar (250 grammes) was now added to a large mixed meal, when it was found not only to increase the amount of work done from 8 to 16 per cent. but increase the resistance against fatigue.

As a concluding experiment, 250 grammes of sugar was added to the meals of a full diet day; causing the work done during the period of eight hours to be increased 22 to 36 per cent.

Mathematical Society, January 11.—Mr. A. B. Kempe, F.R.S., President, in the chair.—The President communicated to the members present the intelligence which had just reached him of the death of Dr. H. R. Hertz, an honorary member of the society. The following communications were made:—"The Types of Wave-motion in Canals," by Mr. H. M. Macdonald; "On Green's Function for a System of Non-intersecting Spheres," by Prof. W. Burnside, F.R.S.

PARIS.

Academy of Sciences, January 8.—M. de Lacaze-Duthiers in the chair.—Studies on the formation of carbon dioxide and the absorption of oxygen by the detached leaves of plants, by MM. Berthelot and G. André. The authors have studied, under the most varied conditions, wheat, *Sedum maximum*, and *Corylus avellana*. Carbon dioxide is evolved from leaves in the absence of oxygen, but much more in the presence of oxygen and moisture. More oxygen is absorbed than is required for the production of the excess of carbon dioxide produced in an oxidising atmosphere. These reactions only occur in the presence of water.—Remarks on a note by M. Dunér, entitled "Is there Oxygen in the Atmosphere of the Sun?" by M. J. Janssen. The author considers M. Dunér's method unable to decide this question, and quotes experimental evidence to show that the effects considered are terrestrial.—Conclusions relative to the manipulation of the soil of oyster parks, and as to the causes of oysters becoming green, by MM. Ad. Chatin and A. Muntz.—On the approximate expressions for the higher terms in the development of the perturbation function, by M. N. Coculesco.—On the influence exercised by solar spots on the quantity of heat received by the earth, by M. R. Savélief. The author discusses the relationship of the activity of the solar surface and the calorific intensity of the solar radiation at the limits of the atmosphere, and draws the conclusion that with increase of solar activity, as evidenced by increase in the number of sunspots, there is increase of calorific intensity.—Thermodynamics of gases. Comparative values of the approximations of Joule's law and of Marriotte's and Gay-Lussac's laws, by M. Jules Andrade. Joule's law and Marriotte's and Gay-Lussac's laws are obeyed by gases within limits of the same order of magnitude.—The law of the magnetisation of soft iron, by M. P. Joubin. The author compares the formulæ representing the intensity of magnetisation of soft iron, in terms of the strength of field and the susceptibility of the material, with Van der Waal's formula for fluids, and concludes that the phenomena of the magnetisation of iron are analogous to the phenomena presented by a saturated fluid, and might be calculated by similar formulæ. Feebly magnetised bodies obey laws analogous to those of fluids far from their points of saturation.—On the absolute value of the magnetic elements on January 1, 1894, by M. Th. Moureaux. The values are given for Parc Saint-Maux and Perpignan.—On the composition of aqueous solutions, according to their indices of refraction, by M. Paul Bary. From the examination of a series of dilute solutions of metallic salts the result is deduced "that, if the theory of M. Arrhénius is admitted, the dissociated salts behave with regard to refraction as if the dissociation does not exist."—Researches on the chemical action of *abrastol* (calcium naphthylsulphonate) on wine, by M. Scheurer-Kestner.—On the presence of poison glands in adders, and on the poisonous properties of the blood of these animals, by MM. C. Phisalix and G. Bertrand. The poisonous principles of adder's blood proceed from the internal secretion of the superior labial glands, and the similarity of these principles to echidnine explains the immunity of the adder for viper poison.—Nitrates in living plants, by M. Demoussy.—On the influence of light and altitude on the striation of the valves of diatomacæ, by Frère J. Héribaud.—The insertion of the spores and the direction of the partitions in protobasidia, by M. Paul Vuillemin.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Geological Survey of Canada, Annual Report, Vol. v. 2 Parts and Maps (Ottawa).—Human Physiology: J. Thornton (Longmans).—The Elements of Co-ordinate Geometry: W. Briggs and J. H. Bryan, Part 1, 2nd Edition (Clive).—Illustrated Guide to British Mosses: H. G. Jameson (Eastbourne, the Author).—A Text-book of Solid or Descriptive Geometry; A. B. Dobbie (Blackie).—A Pocket-Book of Marine Engineering, Rules and Tables: A. E. Seaton and H. M. Rounthwaite (Griffin).—Do you Know it? &c. C. E. Clark (Saxon).—Annuaire de l'Académie Royale des Sciences, &c., de Belgique, 1894 (Bruxelles).—Forschungsberichte aus der Biologischen Station zu Plön; Theil 2: Dr. O. Zacharias (Berlin, Friedländer).—Elements of Synthetic Solid Geometry: Prof. N. F. Dupuis (Macmillan).—Electric Waves: Dr. H. Hertz, translated by D. E. Jones (Macmillan).—Discovery of Lakes Rudolf and Stefanie, 2 Vols.: Lieut. L. von Höhnel, translated (Longmans).

PAMPHLETS.—Guide to the Examinations in Agriculture, and Answers to Questions, Advanced Series (Blackie).—Ditto, Physiology, Elementary Series (Blackie).—Ditto, Elementary Metallurgy, ditto (Blackie).—Ditto, Elementary Principles of Mining, ditto (Blackie).—Ditto, Chemistry, ditto (Blackie).—Test Papers in Mathematics: R. Roberts (Blackie).—Twenty-third Report of the Aëronautical Society of Great Britain (Greenwich, Richardson).—Report on the Destruction of Beer-casks in India by the Attacks of a Boring Beetle: W. F. H. Blandford (Eyre and Spottiswoode).—The Palm Weevil in British Honduras: W. F. H. Blandford (Eyre and Spottiswoode).—Annales de l'Observatoire Magnétique de Copenhague 1892: A. Paulsen (Copenhague). Entwurfeiner Neuen Integralrechnung auf Grund der Potenzial-Logarithmal-und Numeralrechnung, Zweites Heft: Dr. J. Bergbohm (Leipzig, Teubner).

SERIALS.—Actes de la Société Scientifique du Chili, Tome 3, 1 and 2 Livr. (Santiago).—Engineering Magazine, Souvenir No. (New York).—Journal of Anatomy and Physiology, January (Griffin).—American Meteorological Journal, January (Ginn).—Himmel und Erde, January (Berlin).—Xenia Orchidacea, Dritter Band, Sechstes and Siebentes, Heft (Leipzig, Brockhaus).—Mind, January (Williams and Norgate).—Bulletin Astronomique, December (Paris).

CONTENTS.

PAGE

SUPPLEMENT TO "NATURE."

THE STORY OF OUR PLANET.

The Story of our Planet. By T. G. Bonney, D.Sc., LL.D., F.R.S., &c. Pp. 592. (London: Cassell and Co., 1893.)

IN the workshop of science there are many labourers, both skilled and unskilled, and the particulars of their toil, which are not always interesting even to fellow-workers, can seldom be appreciated or even understood by the majority of well-educated persons. The increasing detail of geological work and the number of technical terms introduced, necessary as they are to progress, are calculated to repel not only the unemployed, who might like to gain a general knowledge of the subject, but also the numerous workers in other branches of science, who cannot keep themselves informed on the meaning of the many new terms. Nor can text-books, intended for serious study, be made interesting to the general reader, for the student wants his mental food in a concentrated form, with particulars sufficient for the class-room and examination; while the general reader can only be tempted with the net results of science in a diluted and yet attractive form. Such a reader, too, may approve of the Frenchman's dictum (quoted by William Spottiswoode in his address to the British Association, 1878), that no scientific theory "can be considered complete until it is so clear that it can be explained to the first man you meet in the street." It may, however, take a long time or a big book to do this, though we may agree that conclusions are not of much service unless they are intelligible.

In old days, Lyell's "Principles of Geology," as remarked by Prof. Bonney, "would have been understood with little difficulty by any man of good general education." Twenty-one years have passed since the last edition of that work was published, and we quite agree with the present author that there is "room for a book which covers somewhat the same ground."

The "Story of our Planet" is intended "for men and women of good general education who might desire to know something of the methods of reasoning which are adopted in geology, and of the general conclusions to which these have led." Thinking it would be helpful to get an independent opinion on the book, the writer, after cutting its leaves, placed the volume in the hands of his wife (who is by no means geological), and asked her to read a few pages. She did so, and without a pause read steadily to the end of the first chapter, exclaiming "It is most interesting." This independent testimony was satisfactory, but it requires a little qualification when applied to the volume as a whole. The author commences his work with an account of three specimens, taken almost haphazard, from a collection of fossils. Curiously enough, and perhaps unconsciously, he has returned to an old love, for one of the fossils is *Melania inquinata*, a shell which he obtained thirty-four years ago from the Eocene beds of Charlton, near Woolwich. It is mentioned among others in a short account, perhaps his earliest geological communication, which was printed in the *Geologist* for 1859 (p. 296). Since then the author has wandered in many fields, and has found much happiness of a kind he is wishful to impart to others. Around Cambridge he has examined and written about the Cretaceous and Jurassic strata. He has gone deeper, and discussed the origin of Triassic rocks. Finally, he has descended to the lower regions, and plied his hammer among "The Foundation Stones of the Earth's Crust," as he would call them. Thus from the top to the bottom of the series he has studied the records of the rocks, but ever and anon the vestiges of ancient volcanoes have attracted great attention, and fired an enthusiasm that had, perhaps, to be tempered by many a visit to the Alpine glaciers.

Leaving the first chapter of the book, which, as we have hinted, is well calculated to attract and interest, we are introduced to "The Land Region," and find ourselves confronted with a good many statistics, after which we are led on to the study of the earth's crust and its rocky constituents. Then we come to "The Air Region," in which atmospheric pressure, winds and tornadoes, and rainfall are considered; and pass on to "The Water Region," to an account of oceans and seas, of tides and currents, of snow crystals and glacier ice. This concludes the first part of the work, which is almost wholly devoted to physical geography and meteorology. We had expected to proceed into the "Fire Region," but that is dealt with in Part iii. On the whole, this first part is somewhat disappointing from a geological point of view. Lyell would doubtless have given a good account of the geological results of the *Challenger* Expedition, but these are nowhere summarised.

Part ii. is devoted to the processes of sculpture and moulding, to the polishing of rocks by nature's "sand-blast," to the raising of sand-dunes and the formation of earth-pillars. The formation of escarpments is pointed out, with especial reference to those of the Weald, as explained by Foster and Topley, and the general action of rivers is described. Landslips receive attention; and here the author has himself made a slight slip, for we are told that near Lyme Regis "the cliffs rise to a height of full a hundred feet," but where the great landslip of 1839 took place, the chalk cliffs rise to 400 or 500 feet. "Ice as Sculptor" forms the subject of one chapter, and homely illustrations are given of the bursting of water-pipes, and of the crumbling of mortar and bricks in the jerry-built structures of the nineteenth century, facts which supply the tenant and landlord with useful object-lessons. On the more serious subject of glacier-erosion, the author's conclusions have certainly the weight of personal experience. He believes the effects of a glacier are considerable, but that it acts like a plane or file rather than a chisel or gouge. Yet he admits that the tarns in mountain corries, the lakelets in mountain valleys, may be attributed to the action of ice, but not the broad sheets of Geneva or Constance. The discussion is by no means dead, for quite recently Dr. A. R. Wallace strongly maintains the truth of Ramsay's theory (*Fortnightly Review*, December). "Ice as a Carrier" and "The Work of the Ocean" are duly considered in reference to the transport of material and the carving of features. We now come to the somewhat formidable heading, "The Proletariat of Nature," which may be taken to mean the actions of the lower classes of organisms, some of which are destructive, some protective or constructive. Peat and coal are considered, so also Foraminifera, Radiolaria, and Corals. Part iii. is headed "Changes from Within," and the old Temple of Serapis comes before us as a witness to the fluctuations of level. Movements in the earth's crust, faults, flexures and overthrusts, and the formation of mountains are considered. We pass on to volcanic action and earthquakes, and eventually to the subjects of joints, spheroidal structures, nodules, and mineral veins, all of which are briefly noticed.

In Part iv. we come to to what some may consider as geology proper; or, "The Story of Past Ages." Naturally we most of us like to go back to the very beginning, and glean what knowledge we can of the earth's probable origin; and the author briefly reviews the evidence. More interesting, however, is the chapter which deals with the eras and subdivisions in geological history, and we feel at any rate on *terra firma*. In regard to questions of correlation, the views of Prof. Huxley on "homotaxis" are given more prominence than some students of "zones" will admit to be justified by the present state of our knowledge. Nevertheless, it must be admitted that the philosophy of zones has yet to be understood, and, as the author urges, "geological contemporaneity from the general similarity of fossils must not be pressed too far." Each area must be interpreted as far as possible by its own evidence, and when the sequence of organic remains is found to be alike in areas widely apart, even the highest authorities do not claim precise, but only approximate, contemporaneity.

The Archæan era is one to which the author has paid much attention. It is a complex and comprehensive group, and barren of life, so far as our present knowledge goes. Many crystalline schists and gneisses are provisionally referred to this division, and the author is inclined to regard their general characters as a witness to their age. He points out how evidence to the contrary has in several cases broken down. Still, an attitude of reserve is desirable, when we bear in mind that great earth-movements have taken place in Tertiary times, and that deep-seated metamorphism, as Mr. Barrow has shown in the south-eastern Highlands of Scotland, is all that is wanted to produce the results.

From the chaos of the Archæan era we pass on to a chapter dealing with "The Building of the British Islands," and we are furnished with a brief account of the Cambrian, Ordovician, and Silurian periods. Restorations of the possible geography of Britain in early Carboniferous and subsequent times are given, after Jukes-Browne, and we are led on stage by stage with brief descriptions through the series of formations. With regard to the origin of boulder clay, the agency of coast-ice is maintained in opposition to that of ice-sheets; but in this, as in other cases, where serious alternative opinions are held, the different views are stated.

"The Building of Europe and other Continents" is the next subject provided for us, and we are given a brief sketch of the history of the Alps. Then follows "A Sketch of the Earth's Life History," which might better have been incorporated with the accounts of the several formations whose history was previously told, for the leading types of life are treated stratigraphically. Here, in some respects, the popular meanings given to the names of fossils are more amusing than useful. Thus we have the *Microlestes* or "little thief," the *Dromatherium* or "running beast," the *Turritella* or "cockspur," the *Plesiosaurus* or "neighbour-lizard," the *Pliosaurus* "more nearly a lizard," and so on.

The concluding part is "On Some Theoretical Questions." It deals with the age of the earth, which "is long but it is very far from being boundless." The author, in fact, as stated in his preface, thinks that we can discover "by processes strictly inductive, some sign of its beginning and some foreshadowing of its end." We are not disposed to challenge the statement.

The permanence of ocean basins and of land areas is a well-worn theme, on which "agreement ceases"; but the author is far from dogmatic on the subject. The problems of climatal change and of the distribution of life on the earth, form the topics discussed in the closing chapters.

The general reader who peruses this volume cannot but gain a sound general knowledge of geological science. In the ordinary sense of the term we cannot call it a very "popular" book, for it contains too much solid reading to please those who would read for entertainment. It must be read by those desirous of instruction; by them it will be appreciated, and for them we believe the work has been written. To the more serious student it will be of service in regard to Prof. Bonney's views; but as a work of reference it lacks importance, from the fact that the author does not, as a rule, cite original authorities, but gives references mainly to text-books and other works of a general character. That he has laboured with enthusiasm, and lightened his labours with many a pleasant, and sometimes a pungent, remark on things in general, will be evident to all who take up this volume.

CAYLEY'S PAPERS.

The Collected Mathematical Papers of Arthur Cayley, Sc.D., F.R.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge. (Cambridge: University Press, 1889, *et seq.*)

LATE in the year 1887 the Syndics of the University Press requested Prof. Cayley to allow his mathematical papers to be reprinted in a collected form. To this he acceded, and also undertook the work of superintending the impression and of adding such notes and references as appeared to him desirable.

Cayley's papers, commencing in the year 1841, have appeared in every periodical mathematical publication of importance in Europe and America. A worker in pure mathematics, in whatever special department of geometry or analysis, is well-nigh certain to find that his subject has come under Cayley's hand, so comprehensive are the researches that he has presented to the scientific world. A study of one or more of these papers being thus inevitable, it is easy to appreciate the importance to a student of this wonderful collection—wonderful alike in regard to extent, to variety, and to quality. It is not our intention to attempt a sufficient review of the six volumes that have appeared in the five years that have elapsed since January, 1889. If this were the end in view, a volume would be necessary. On this occasion we purpose to glance rapidly at some of the great discoveries, here set forth, which will be for ever linked to the Professor's fame.

The first volume comprises 100 papers, numbered consecutively and nearly in chronological order, produced between the dates 1841 and 1853. The paper No. 13, "On the Theory of Linear Transformations" (1845), marks a distinct epoch. Boole, in 1843, had proved the invariantive property of the discriminant of a quantic homogeneous in *m* variables, and Hesse, in 1844, had established certain covariantive properties of the ternary cubic. Here we find the general problem of "invariants" proposed, and some progress made towards its solution. The first step was the generalisation of Boole's theorem to a quantic of order *n*, containing *n* sets of *m* variables, the variables of each set entering linearly. This led to a function of the coefficients which possesses Boole's invariantive property, but it was not the discriminant as first pointed out by Ischläfli. This function, however, was seen by Cayley to necessarily satisfy a certain system of partial differential equations, and he was thence led to the capital discovery that a class of functions satisfied the same equations, and that each member of the class possessed the invariantive property. Other papers followed, and finally, in the year 1854, Cayley commenced the series of memoirs on Quantics which at intervals during the succeeding five-and-twenty years appeared in the *Philosophical Transactions* of the Royal Society. In this way the theory of algebraic invariants was gradually evolved. To this result there were many other contributors, notably Sylvester (to whom most of the nomenclature is due), Salmon, and Hammond in this country, and Aronhold, Clebsch, Gordan, and Hilbert in Germany. The first six memoirs are presented in vol. ii. of the collection. In vol. i. may be noted also the theory of conics of involution in connection with curves of the third order; the theory of "Pfaffiaus"; and the theory of surfaces of the third order. The last paper mentioned—a very important one—was developed in a correspondence with Dr. Salmon, to whom is attributed the enumeration of the twenty-seven lines on the surface. In vol. ii. we find in the notes which conclude the volume an account of the early bibliography of the theory of invariants; also the remarkable memoir on the theory of matrices, a subject which, at the present day, is exhibiting considerable vitality. The memoir appears to have been overlooked by mathematicians for more than twenty years after it appeared in 1858. The single exception appears to have been the paper by Laguerre, "Sur le Calcul des Systèmes Linéaires" (*Jour. Ec. Polyt.*, t. xxv.), in 1867. However, the subject was ultimately taken up by Sylvester, in his "Lectures on Multiple Algebra," in the *American Journal of Mathematics*, and is now an important branch of pure mathematics, both in its results and in its ideas. The volume is also remarkable for researches on the "Partitions of Numbers," "Skew Symmetric Determinants," the "Theory of Groups," "Caustics," and "Curves of the Third Order."

Vol. iii. contains notably the contributions to dynamics and astronomy. There is the valuable "Report on the recent Progress of Theoretical Dynamics," from the "Report of the British Association for the Advancement of Science, 1857." The review extends from Lagrange, 1788, to Bertrand, 1857. It, principally, gives an account of the notable contributions of Lagrange, Poisson, Sir W. R. Hamilton, and Jacobi. There are papers on Lunar Theory, Elliptic Motion, and the Problem of Three Bodies; also an extensive series of "Tables of the Development of Functions in the Theory of Elliptic Motion." The paper (No. 221) "On the Secular Acceleration of the Moon's Mean Motion" is interesting as supplying an independent verification of Prof. Adams' correction of Plana's expression for the true longitude.

Vol. iv. is chiefly remarkable for the "Report on the Progress of the Solution of certain Special Problems of Dynamics," from the Report of the British Association for the Advancement of Science for the year 1862. At the commencement the author adverts to a serious omission in his former report in volume iii. This has reference to the memoir by Ostrogradsky, "Mémoire sur les équations différentielles relatives au problème des Isopérimètres," *Mém. de St. Pét.* t. iv., 1850, which contains, in the most general form, the transformation of the equations of motion from the Lagrangian to the Hamiltonian form, and also the transformation of the system arising from any problem in the calculus of variations to the Hamiltonian form. The remark is also made that in a work by Cauchy, "Extrait du Mémoire présenté à l'Académie de Turin le 11 Oct., 1831," published in lithograph under date Turin 1832, there is satisfactory evidence that Cauchy, in the year 1831, was familiar with the Hamiltonian form of the equations of motion. Mention is made of papers on theoretical dynamics, notably by Bour, Jacobi, Natani, Clebsch, and Boole, which had appeared subsequent to the writing of the first report.

The second report includes various problems relating to the "particle" and the "solid body," "the problem of three bodies," &c. A list of memoirs is added, and increases the historical value of the report. One paper, No. 265, "Addition to the Memoir on an Extension of Arbogast's Method of Derivations," is published in this volume for the first time. The general subject of "quantics" is resumed in a seventh memoir, which is principally devoted to ternary forms. An important paper is that on the "Theory of Equations of the Fifth Order." The quintic equation cannot be solved algebraically. By the "resolution of the quintic" mathematicians understand the expression of its roots in terms of those of its resolvent sextic. During the fifteen years preceding 1861 considerable progress had been made with this problem by Cockle and Harley. In the year mentioned Cayley obtained a new auxiliary sextic equation, and showed that the roots of the quintic are, each of them, rational functions of its roots. A fresh impulse was given to the subject by George Paxton Young and Emory McClintock in vols. vi. and viii. of the *American Journal of Mathematics*, 1884-1886. The former indicated the general form of the roots of the quintic, and the latter made it possible to directly and visibly express them. In a long note at the end of the volume Prof. Cayley supplies the links between his own work and the later work of McClintock, which he considers very important and remarkable. In vol. v. there are two papers on the theory of curves in space, and in the "notes" the Professor gives his present views, taking into consideration the later work of Halphen, Nöther, Valentine, and Hilbert. These authors make considerable use of Cayley's conception of the monoid surface, the curve being regarded as the partial intersection of a cone with a monoid surface; Halphen obtained the fundamental theorem which shows the existence of a monoid surface of order $n + 1$, where n is the order of the cone of lowest order which passes through all the nodal lines of the aforesaid cone. Important remarks are made on the theory arising from this notion. In the Professor's view, the question of the *classification* of curves in space, according to the representation, as the partial intersection of a cone and a monoid surface is that which properly first presents itself.

There are many papers on geometry, including those on "skew surfaces" and "sextactic points of a plane curve," with which all geometricians are familiar.

The paper No. 347, "On the Notion and Boundaries of Algebra," considers in particular the line of separation between finite and transcendental analysis. The views of so eminent a man on this subject are necessarily of interest and importance. In stating algebra to be both an art and a science, the author is in agreement with the constantly reiterated opinion of Prof. Sylvester, and indeed with that of the great majority of those who have made algebra a subject of special study. The two great divisions of algebra are stated to be "tactic" and "logistic," and the remark is made that every algebraical theorem rests, ultimately, on a tactical foundation. Mathematicians will, we think, perceive in the word "tactic" a singularly felicitous expression to denote those operations which relate to arrangement of mat rial.

The paper No. 312, "On the Partitions of a Close," generalises Euler's polyhedral relation,

$$F + S = E + 2$$

and is a first step towards Listing's well-known developments.

The frontispiece of vol vi. is a portrait of Prof. Cayley, attired in gown, seated at his desk in the act of writing. The picture is somewhat dark and not quite so pleasing as those which of recent years have appeared in NATURE and in the *American Journal of Mathematics*. The volume is principally on geometry. The memoir No. 412, on "Cubic Surfaces," adopts a classification depending on the nature of the singularities. In the notes the notation is compared with that of Zeuthen, and several apparent discrepancies in the results are explained.

There is a long memoir on the polyzomal curves

$$\sqrt{U} + \sqrt{V} + \ldots = 0$$

U, V, &c., being rational integral functions of the same degree in the variables. The general v-zomal curve (*i.e.* v functions U, V, &c.) is considered, and the branches, singularities, order, class, &c., determined. The investigation is intimately connected with Casey's work, on Bicircular Quartics, published in 1867 in the Proceedings of the Royal Irish Academy.

Other geometrical subjects considered are "Reciprocal Surfaces," "Skew and Developable Surfaces," "Abstract Geometry," "Cubical Divergent Parabolas," &c. In analysis we have the eighth memoir on quantics, which relates chiefly to the binary quintic; and, finally, mention may be made of the reproduction of Euler's memoir of 1758, on the rotation of a solid body.

The number of papers which appear in the six volumes is 416. Several hundreds of papers have yet to appear, and it seems improbable that a total of ten volumes will be found sufficient. This improbability is increased from the circumstance that Prof. Cayley is still producing a considerable amount of mathematical work.

For excellence of mathematical printing, and general care of production, unstinted approval may be awarded to the Cambridge University Press. These handsome volumes, as they appear, are rearing a fitting monument of the work of an eminent man, and are causing gratification and congratulation amongst mathematicians the world over.

P. A. MACMAHON.

THE PAMIRS.

The Pamirs: being a Narrative of a Year's Expedition on Horseback and on Foot through Kashmir, Western Tibet, Chinese Tartary, and Russian Cental Asia. By the Earl of Dunmore, F.R.G.S. In two volumes. (London: John Murray, 1893.)

LORD DUNMORE embodies in these volumes the journal of a somewhat remarkable journey of a year's duration, the initial and terminal points of which were Karachi and Constantinople. During most of the time he was accompanied by Major Roche, and the object of the journey was sport, especially the pursuit of the *Ovis poli*. Unfortunately this great sheep—of which Lord Dunmore (vol. ii. p. 56) appears to doubt the ovine character—inhabits a country the political geography of which is still undergoing spasmodic evolution, and there is reason to suspect the censorship of the Indian Government on all English writings bearing on the region. Thus we cannot expect any great contributions to the detailed topography of the Pamirs to be made public, and as the author makes no claim to any scientific acquirements, the botany and geology of the vast tracts wandered over are left no clearer than they were before. Major Roche, however, made an entomological collection. It is deeply to be deplored that every traveller, who is so fortunately circumstanced as to be able to push his way where few intelligent Europeans have been before, should not make some sort of preparation to fit himself for utilising his rare opportunities. For such preliminary instruction in science the Royal Geographical Society has made ample provision specially adapted to the wants of travellers, and as years go on we trust that the imputation of ignorance of what and how to observe may no longer be the necessary prelude to the criticism of works of travel in a scientific journal. Major Roche was fortunately provided with a camera, and made splendid use of it, although most of his negatives were unfortunately destroyed. Lord Dunmore himself is something of an artist, and much value must be attached to the landscapes which illustrate his book. Both travellers carried aneroids and, presumably, some surveying instruments, as a map with several new features is one of the results of the journey. We may point out that the larger-scale map of the Pamirs should have been bound with vol. ii., in which alone that region is discussed, while the general map showing the route to Yarkand would be more useful in vol. i. One other criticism must be made before turning to the pleasanter

FIG. 1.—Ovis Poli.

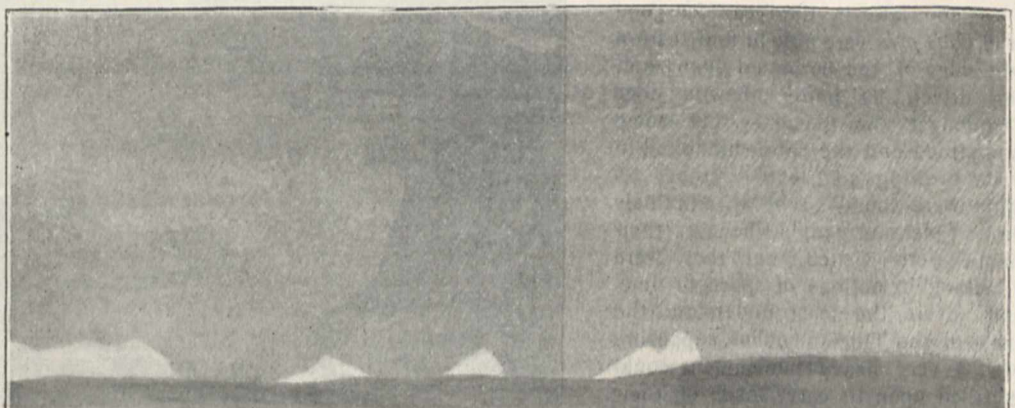

FIG. 2.—The Roof of Asia, plateau 18,000 feet above sea-level.

consideration of the merits of the work. Native words are introduced in unnecessary profusion, and although *akoi*, *jigit*, *puttoo*, and seventy-five other uncouth terms are interpreted in a glossary considerately prefixed to each volume, we can only guess darkly from the context the significance of *chikore*, *chit*, and *fank*, to mention only a few we have puzzled over.

Lord Dunmore has travelled extensively in many parts of the world, and he is able to brighten his descriptions by many shrewd comparisons with distant places and diverse peoples. His power of description is above the average of the sporting traveller, and from first to last the two volumes may be read with pleasure and with profit. It is particularly pleasing to notice the reticence regarding his own doings, and the generous recognition given to his native attendants and the merchants and officials who showed his party kindness by the way.

Starting from Rawal Pindi on April 9, 1892, Lord Dunmore passed through Kashmir to Leh over familiar ground, climbed the Laoche Pass (18,000 feet) on yaks, crossed the Shyok valley, the scenery of which appeared on a grander scale than any in the Rocky Mountains, and completed the outfit of the expedition at Panamik, the last outpost of civilisation. On July 1, the expedition, including 30 men, 60 yaks, and 56 ponies, left Panamik, crossed the great Dapsang Plateau, an undulating plain averaging over 16,000 feet of elevation, which Lord Dunmore names "the Roof of Asia," easily surmounted the Karakoram Pass (about 19,000 feet, but all these measurements varying within a few hundred feet as determined by different aneroids), and reached Yarkand on August 4, after passing through the finest scenery of the whole journey. For eight days they camped at elevations exceeding 17,000 feet, but experienced no difficulty from mountain sickness. At Yarkand fresh supplies were laid in, and on August 18 the expedition set out again, crossed the waterless desert of Shaitan-kum, penetrated the difficult "Sariq-qol" country, and on September 6 formed a permanent camp in the Kukturak valley of the Taghdumbash Pamir, at an elevation of 15,000 feet. It was too late in the year for good sport, as the *Ovis poli* were able to find pasture close to the edge of the perpetual snow, and were often driven by herds of wild dogs right up amongst the glaciers; but some sport was obtained and the camp inhabited in spite of the growing cold until October 30. The Kirghiz were found to be an extremely hospitable and pleasant people whenever their encampments were visited, but they were curiously lacking in notions of space or time. They could not in the least understand the laboriousness of the Tibetan coolies, supposing that only as a very heavy punishment could people be called upon to carry loads on their heads, or travel on foot. The journey now led zig-zagging across the Pamirs, in bitterly cold weather, past frozen lakes and along the beds of frozen rivers to Kashgar. Lord Dunmore crossed the source region of the Oxus, and speculates as to which of several tributaries, rising within a few miles of each other, but pursuing widely devious routes, is the true "high mountain cradle in Pamere." From a geographical point of view such a discussion is vain, since only an accurate survey could decide which stream of all the streams was the longest, highest, or possessed of the greatest drainage area, and then it is a matter of hair-splitting definition to determine whether one or another of several nearly equal tributaries should retain the name of the main stream. There is, we imagine, no system akin to primogeniture which could discriminate the rights of the twin or triplet sources of the Amu-daria to exclusive physical continuity with the mature river in which they all converge. The similarity of the name Aksu, which belongs to one of them, with the name Oxus, even if, as Lord Dunmore urges, not accidental—which it certainly is—could only prove that an earlier and more ignorant generation had imagined some sort of continuity. On Lake Victoria, in the Great Pamir, a thousand miles from the sea, Lord Dunmore reports that he saw a common seagull, but he did not secure the specimen. He also discovered a new pass leading to the Alichur Pamir, to which he gave the name of Hauz Dawan, from a remarkable cistern-like lakelet which occupied its summit. Following up the Alichur river and crossing the Rangkul Pamir, the caravan wound its way through the long Gez defile which forms the narrow access to Kashgar, and after a short stay under Chinese protection, took the road to Osh, in Russian territory, where it was disbanded on January 1, 1893. Major Roche returned to Kashmir, the Russian officials not allowing him to cross the frontier, and Lord Dunmore proceeded by tarantass and sledge through Khokand and Tashkent to Samarkand, whence the trans-Caspian Railway brought him back to Europe.

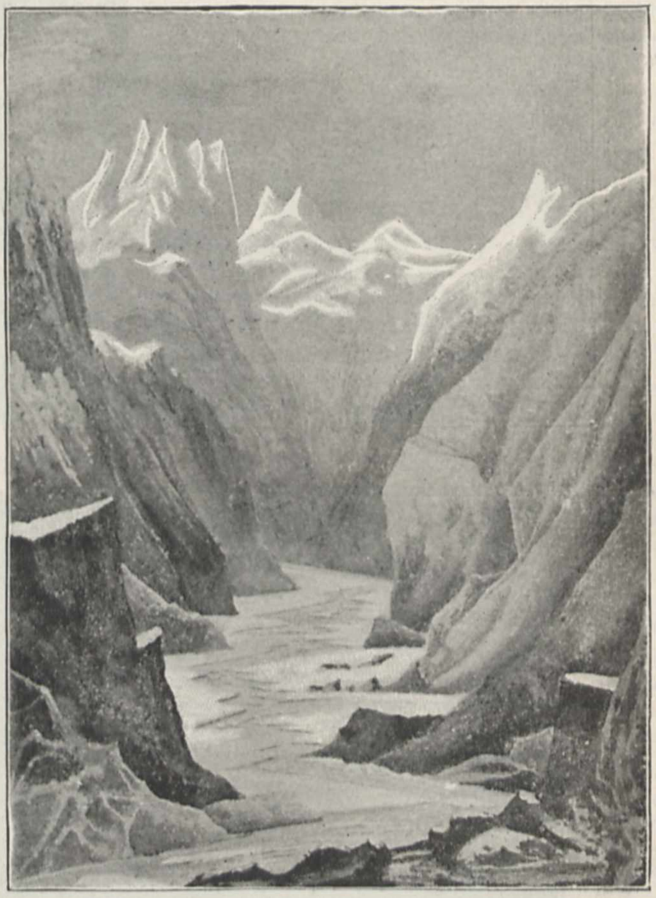

FIG. 3.—The Gez defile.

The meteorological data obtained are incomplete, as the registering thermometers were only graduated to

−20° F., and could not be left outside the tents at night for fear of damage to the index by the low temperatures experienced. They are not tabulated, nor is there a detailed itinerary, but an interesting appendix shows graphically the heights of the various passes as compared with the summit of Mont Blanc.

The illustrations reproduced are selected from a profusion of admirable pictures. Fig. 1 represents the *Ovis poli* in their summer feeding-grounds close to the snow-line, and the others are typical of the most impressive plateau and gorge scenery of the region.

THE GENUS MADREPORA.

Catalogue of the Madreporarian Corals in the British Museum (Natural History). Vol. I. "The Genus Madrepora." By George Brook. (London, 1893.)

IT is with feelings of sad regret that we turn over the pages of this monograph. Mr. Brook laboured long and hard at the book, carried it through the press, but did not live to see his labours recognised by his colleagues. His sudden and premature death has already been noticed in NATURE (vol. xlviii. pp. 376, 420), and the present writer would like to add his testimony to the accurate and painstaking character of the work of George Brook. Happily free from pecuniary anxiety, he was able to, and did, devote his time to scientific work without regard to its paying qualities, either as to money or to immediate scientific reputation.

The monograph now under review was to be the first of a series of memoirs on the classification of the Madreporaria which were to form part of the great series of the catalogues of the British Museum. As a detailed account of the anatomy of soft parts, of histology, and of morphological problems is foreign to the general plan of this series, we must not expect to find these subjects fully dealt with in this volume; but Mr. Brook does give a succinct account of the anatomy of the genus Madrepora, so far as is at present known. For some years Mr. Brook had been studying the anatomy of the Madreporaria, and in due time he would have published his results, which would have been of great value. It is to be hoped that what has already been accomplished by him, but not yet published, will not be lost to science.

The name Madrepora appears to have been first used by Imperato in 1599; but its precise significance, or rather the sense in which the term was originally employed, does not appear to be generally understood. Imperato clearly regarded what we now speak of as the "corallum" as a stony "nurse," in the porous cups of which animal polyps undergo their development, and "stony mother" appears to indicate the meaning intended. There is no doubt that the word is, in the first instance, Italian, and Linnæus applied it to the same group of zoophytes as Imperato had done. As, however, the term was originally used to indicate the "maternal" character of the "stone" rather than its porosity, it appears that the root should be referred to the Greek πῶρος, *i.e.* stone, and the English pronunciation of the word altered accordingly. There is no need to detail here the complicated synonymy of the name; it is evident that its retention depends for its justification on custom rather than on priority. Dana and all subsequent writers, except Ehrenberg, have followed Lamarck who retained Linnæus's name for non-typical species (*M. muricata*) of the original species. Ehrenberg proposed in 1834 a new name (Heteropora) for the restricted genus as we now know it, but unfortunately his name had been preoccupied by Blainville. Prof. F. Jeffrey Bell (*A. N. H.* viii. 1891, p. 109) has also shown that the name "Holothuria" is in an analogous position. In these and similar cases, good sense, rather than a rigid adherence to rules of priority, should determine the retention of a well-known name, especially when zoologists are agreed as to the forms which are included under the term in question; but in the great majority of cases it is better to adhere to the generally accepted rules.

Dr. Duncan (*A. N. H.*, 1884, p. 181) has given an account of the structure of the corallum in three varieties of growth. As was to be expected, the quick-growing species have a lax tissue, while the slow-growing forms are very dense. Mr. Brook objects to the use of the term "costæ" for the external longitudinal ridges on the wall. The porous corallite wall is essentially composed of synapticulæ, and is therefore not a theca, as it differs both in structure and origin. According to G. von Koch's view of the origin of a theca, costæ are to be regarded as the distal extremities of septa which pass beyond the thecate wall. In the genus Madrepora the so-called costæ undoubtedly do not come under this category. They appear before the septa, and bear no regular relation to them, either in number or position.

Although the Anthozoa are generally regarded as typical radiate animals, those who have studied their embryology and anatomy recognise a fundamental bilateral symmetry which is masked by the tendency to a radial habit which characterises sessile forms. The typical number of septa is 12, viz 6 primary and 6 of a second cycle, which is usually less developed; rarely a third cycle occurs; in many species the primary cycle alone is present. The septa are generally most fully developed in the axial corallites. It is often stated as characteristic of the genus Madrepora that the axial or directive septa are more prominent than the other primary septa; but this is by no means always the case, nor is that condition confined to the genus. Whilst in axial corallites the most usual arrangement is for the primary septa to be sub-equal, in the radial corallites the directive septa are most frequently better developed—either stouter or broader—than the other primaries. In certain groups of species, however, the outer directive septum is more important than the inner; and in case only one septum is present, it is invariably the outer directive. It appears that in these cases the corresponding tentacle is longer than the remaining eleven.

For a knowledge of the soft parts, we are mainly indebted to Dr. Fowler (*Q. J. M. S.* xxvii. 1886, p. 1), although Mr. Brook did not omit to make investigations on his own account. The structure of the polyp is, in its general features, Actinian, but there is a marked bilateral arrangement of parts. The corallum is penetrated by an intercommunicating series of canals which put the cœlentera of all the polyps into communication with each other. The mouth is elongated in the sagittal axis. The stomatodæum is supported by twelve mesenteries. The two pairs of directive mesenteries, and one mesentery on each side (Nos. 4 and 9 of Fowler's Fig. 8)—which, as in the Antipatharia, may be termed the transverse mesenteries, and are the first to be developed—are more important than the others, and extend to a lower level; they are also the longest, and are the only ones which bear reproductive organs. Similar elongate mesenteries occur in Alyonaria, in Antipatharia, and in Seriatopora and Pocillopora amongst the Madreporaria. In Antipatharia, also, they are the only ones which bear reproductive organs. The present writer has more than once (Trans. Roy. Dublin Soc. iv. 1889, p. 300; Proc. R. D. S. 1890, vii. p. 128) suggested the employment of names for the primary mesenteries which are independent either of empirical numbers or of the order of their appearance in ontogeny. According to that enumeration, here, as in the Actiniaria generally, the first mesenteries to appear are the sulculo-sulcar laterals (Lacaze Duthiers' 1, and Fowler's 4 and 9). In *Madrepora Durvillei* the other important mesenteries are the sulculo-sulcular laterals and the sulcar directives, to which must be added in *M. aspera* the sulcular directives. The inconspicuous mesenteries are the sulco-sulcar laterals and the sulco-sulcular laterals (with the addition of the sulcular directives in *M. Durvillei*). There may be details of structure peculiar to certain species of Madrepora, or even to individuals, as in dimorphic forms; but the relative values of the several mesenteries can be matched in the young and in some adults of the Actiniaria, and in the larva of Euphyllia, and among other Madreporaria.

We cannot enter into the question of classification or the characters upon which classifications have been based; suffice it to say that Mr. Brook relies primarily on the structure of the corallum. Very little is yet known upon the arrangement of the soft tissues in their relation to the corallum. It is to be expected that the varied skeletal characters are the outcome of a difference in the structure or arrangement of the soft parts; in the meantime the corallum is all there is to deal with, and the author has naturally assumed that a similarity of structure involves a close relationship, and therefore places little reliance on habit. To a certain extent the species fall into well-marked groups, if one does not regard habit of prime importance. The genus is divided into ten divisions or sub-genera; the chief place is given to the character of the axial corallite (this is analogous to the growing point of the stem or branches of a plant), and secondly to that of the radial corallites which are produced by means of indirect budding around the wall of an axial corallite. The texture of the corallum is also an important diagnostic feature, and of least value is the mode of growth or habit. We are at present quite in the dark as to the reasons why individuals of the same species should grow in a flabellate (or palmate) manner, or be luxuriantly arborescent; there is, however, a general tendency for the members of a morphological group to have a similar habit of growth.

Those who have attempted to name specimens of madrepores from the older descriptions will welcome this masterly monograph; but it is to be regretted that outline figures illustrating the details employed in classification were not appended to the synopsis of the sub-genera on p. 22. The collotype plates, although beautifully executed, illustrate more the general habit, and the critical characters therein are not readily discerned.

The genus Madrepora contains a large number of species. Mr. Brook recognises 221, of which the British Museum has 180 species out of a total of over 1100 specimens. Mr. Brook reduced 169 old species to 130 in number, but has been obliged to describe 91 new species; of these 62 appeared in the *Annals of Natural History* for 1891 and 1892. No fossil representatives are alluded to. Mr. Brook had travelled extensively in Europe in order to study the type specimens in various museums, but he had not seen the types in American museums. Eighty-six species are illustrated in the twenty-five plates, which are beautiful collotypes by Messrs. Morgan and Kidd, from the author's own negatives. Owing to the necessity for large plates the monograph is quarto in size, instead of the usual octavo of the other catalogues of the British Museum.

It is by no means an easy task to identify the species of this genus, owing to their number and varied habit. The genus Madrepora is now flourishing abundantly, and it is difficult in some cases to determine whether certain forms should be regarded as species or varieties. It is widespread, abundant, and variable forms, such as these, which are the despair of old-fashioned systematists, but serve as stimulating problems for the modern naturalist.

ALFRED C. HADDON.

PHYSIOLOGICAL CHEMISTRY.

Physiological Chemistry of the Animal Body. By Arthur Gamgee, M.D., F.R.S. Vol. II. The Physiological Chemistry of Digestion. (London: Macmillan and Co., 1893.)

THE examination of the subject of physiological chemistry may obviously be made from two separate points of view. In the first place, the different problems of the subject may be discussed from the standpoint of the organic chemist, who looks to physiology for illustration and extension of truths established by laboratory practice. In the second place, the various chemical processes occurring in the animal body may be considered from the biological standpoint, and here the domain of chemistry is invaded simply as far as necessity compels for the adequate comprehension of the biological problems presented.

The result of writing a treatise from either of these points of view alone is to largely limit the usefulness of the work, and yet it requires no inconsiderable courage to attempt to furnish a work which may be of important service both to the chemist and biologist. Dr. Gamgee has, however, been inspired with the courage of his well-recognised ability, and has presented the scientific world with a work which must at once appeal to the chemist for the thoroughness of its chemical explanation and detail, and to the biologist for the general completeness of its critical review of physiological work.

Dr. Gamgee expresses the hope that the text-book may supply a want which is at present experienced of some guide to the more advanced student and original worker. The fulness of the references given in the work alone would warrant this hope being fulfilled; and the fact that some of the most recent work is included in the volume will not lessen its anticipation. The author has not confined himself to purely physiological considerations. The pathology of jaundice, the pharmacology of icterogenic poisonous agents, the formation of gall-stones, and the nature of the gastric contents in different pathological conditions, are all treated with an amount of fulness that might not be expected in a work on physiological chemistry.

In addition to the general record and criticism of physiological work, all the important analytical methods are supplied, and it will be to some an encouragement to know that Dr. Gamgee has himself tried, as far as possible, all the experimental processes mentioned.

The present volume does not complete Dr. Gamgee's treatise on physiological chemistry. He proposes, after re-editing the first volume, to finish his work with yet another volume giving the results of a study from the chemical point of view of other animal functions. We may be permitted to express the hope that circumstances will favour the elapse of a much shorter interval than has occurred between the publication of volumes i. and ii. At the same time, the vast amount of important work that has been done during the last decade, and which has largely revolutionised our ideas of the physiological chemistry of digestion, makes the present time auspicious for the presentation of a record of such work.

The present volume is divided into thirteen chapters of varying length. The first is occupied with a consideration of *saliva*. The most recent views as to the constitution of the starch molecule, and the results of the action upon it of a diastatic ferment, are well described.

The second chapter, however, which treats of gastric digestion, will probably be regarded as the most important in the book. It commences with a short histological account of the structure of the stomach. We think that these short histological descriptions are out of place in the present work; they are not sufficiently full to be of much value to those who are likely to have occasion to use the book. The histological preliminaries are succeeded by a historical account of our knowledge concerning gastric digestion, in which the views of Van Helmont, Sylvius, Borelli, Réaumur, and Spallanzani are recorded. The nature of pepsin, the method of preparing artificial gastric juice, the nature of the acid of the stomach, are all treated upon with considerable detail. Then follows an account of the changes occurring in proteids by the action of gastric juice. After referring to the views of Meissner, Brücke, and Schutzenberger, the author goes on to record the observations and views of Kühne. The large amount of work done in recent years by Kühne, Chittenden, and Neumeister in the direction of refining our knowledge of what a few years ago was called *peptone*, is fully described. We are disposed, however, to take part with Halliburton in preferring the term *proteose* to that of *albumose*. Dr. Gamgee considers that a confusion might arise between the term *proteose* and *proto-albumose*, and prefers the general term *albumose*. But the difficulty at present experienced of causing students to understand that albumose can be derived from other proteids than albumin makes the confusion suggested by Dr. Gamgee a comparatively insignificant matter. When the terms *globulose*, *caseose*, and so on exist, it is obviously unscientific to retain the term albumose as embracing all these bodies. We are hopeful, therefore, that the change suggested by Halliburton will gradually find its way into our physiological text-books.

The milk-curdling enzyme of the stomach is referred to, and a brief account of the change that milk undergoes by its action is given. Dr. Gamgee prefers to leave a detailed consideration of these changes to a later volume dealing generally with the chemistry of milk. We think it is more desirable to treat of the change milk undergoes at the instance of a ferment in the stomach in connection with gastric digestion than at any other place. There is a rather unaccountable inconsistency in Dr. Gamgee's reference to absorption of water in the stomach. On p. 154 he states in the paragraph indicator that the stomach is "the seat of absorption of much water." In surveying the work on this subject later (p. 439 *et seq.*) he describes how recent research has established beyond a doubt the fact that the stomach does not absorb water at all (p. 441, line 20).

The third chapter treats very fully of pancreatic digestion, and appears with that on bile (chapter iv.) to be amongst the best in the volume. In connection with the latter the author has given us some very beautiful reproductions of MacMunn's spectra of bile-derivatives. The nature of the albuminoid substance of bile is referred to, and the fact that it is no longer to be regarded as *mucin*, but as a *nucleo-albumin*, is emphasised. The nature of nucleo-albumin is also briefly described. The digestive processes occurring in the small intestine are treated of in chapter ix. The different methods of experimenting are fully described. As regards the action of the enzyme of the intestinal juice, we think Dr. Gamgee has been somewhat over-influenced by tradition, which has led him to attach perhaps too much importance to its existence and action. And the fact that observers have always experienced more difficulty in obtaining positive results with extracts of the fresh mucous membrane than with so-called intestinal juice, justifies us in accepting with considerable caution inferences based upon observations on so-called permanent fistulæ.

The last chapter is devoted to a description of intracellular digestion in lower invertebrata, the digestion occurring in fishes, birds and ruminants, and supplies a becoming sequel to a comprehensive work.

Appendices are added, giving in more detail Neumeister's views concerning the albumoses, some very recent work of Kühne on the separation of albumoses and peptones; also some additional methods for the detection and estimation of the acidity of the stomach.

We should have preferred to see the index divided into two portions—one treating of subjects and the other of authors. A few mistakes occur in it, but only of trifling importance; however, it has the defect of being somewhat incomplete.

Taken altogether, we have only congratulation to offer to Dr. Gamgee on the production of this work, and have no hesitation in stating that he is certainly justified in hoping, as he does in the preface, "that the present volume may . . . further the advancement of, and prove not altogether unworthy of, the present position of Physiology in England." J. S. EDKINS.

AN ESSAY ON NEWTON'S "PRINCIPIA."

An Essay on Newton's "Principia." By W. W. Rouse Ball. (London: Macmillan and Co., 1893.)

THE name of Newton has become now quite a household word amongst us, and one instance of its familiarity was strikingly brought home in an answer given by a small child, who when asked who was Newton, replied, "the man who found the first apple!" That two important epochs in the world's history should have been marked by the presence of this fruit, seems curious indeed; and Mr. Ball informs us that the apple anecdote in Newton's case rests on good authority, for besides written evidence, local tradition confirms it by the careful treatment the tree received, which kept it alive until the year 1820.

For the essay which we have before us, Mr. Ball should receive the thanks of all those to whom the name of Newton recalls the memory of a great man. The "Principia," besides being a lasting monument of Newton's life, is also to-day the classic of our mathematical writings, and will be so for some time to come. During Newton's lifetime three editions of this great work were brought out, the first appearing in 1687; the second, edited by Cotes, in 1713; and the third, by Pemberton, in 1726. Since the last-mentioned date, the history of the "Principia" has been discussed by Sir David Brewster and Prof. S. P. Rigaud, but both of these works are now out of print and very scarce. At the present time, as Mr. Ball informs us, it seems fitting to collect, from these and other sources, the references to the leading events in the preparation and publication of the "Principia," and the present volume contains the result of his labours. In the subject-matter, of course, there is much that is not new, but the value of the work lies in the fact that, besides containing a few as yet unpublished letters, there are collected in its pages quotations from all documents, thus forming a complete summary of everything that is known on the subject.

Mr. Ball divides his essay into six main sections, dealing with Newton's investigations in 1666, in 1679, in 1684, in 1685-1687, compilation and publication of the "Principia," the two last treating of the contents of the "Principia," and the subsequent history and preparation of later editions.

Mr. Ball commences with the works of Newton at the time when the latter had taken his degree at Cambridge, and therefore had more leisure to pursue his studies in his own way. The reader is made acquainted with Newton's early views, and there are several interesting quotations from some original manuscripts inserted. The investigations of 1879 refer, in great part, to the correspondence he had with Hooke, which turned his attention to the problem of planetary motion. It was in this year that Newton suggested the method of demonstrating the earth's motion of rotation on its axis by the letting fall of a stone from a high position, and observing the direction of the deviation from the vertical; he also repeated his calculations (with new data) for finding the relation between terrestrial gravity and the centripetal force which retained the moon in her orbit.

In 1684, Halley, after attempting to deduce the motion of the heavenly bodies from Kepler's laws, with unsuccessful results, made a visit to Cambridge, when he found that Newton "had brought this demonstration to perfection." During that year Newton gave in his professional lectures an account of his work then in manuscript form, entitled, "De Motu Corporum," which may be said to be "a rough draft of the beginning of the first book of the 'Principia.'" This period includes also Halley's second visit to Cambridge with reference to Newton's publication of this tract, and it was at this time also that Halley asked him to communicate his results to the Royal Society. The tract which Newton finally communicated was entitled, "Propositiones de Motu," and may be looked upon as marking the point at which Newton had arrived about the end of this year. Mr. Ball reproduces this tract *in extenso*, as it has only once been printed, and copies of it are scarce.

The fifth chapter deals with the investigations from 1685 to 1687, during which time Newton was preparing the "Principia." A most interesting account is given of the details concerned in the preparation of the subject-matter, while he refers also, by no means too fully, to the extreme generosity that Halley displayed, both as regards the cost of printing the books, and also to the interest he took in their progress, criticising some parts, and revising sheets for press. Rigaud, in his essay on the first publication of the "Principia," referring to this point, says, "that under the circumstances it is hardly possible to form a sufficient estimate of the immense obligation which the world owes in this respect to Halley, without whose great zeal, able management, unwearied perseverance, scientific attainments, and disinterested generosity the 'Principia' might never have been published." Mr. Ball also discusses here briefly Newton's controversy with Hooke, "the universal claimant," as he was called.

Chapter vi. is devoted to an analysis of the "Principia," a few words of introduction relating to the main differences between the first editions being given. Mr. Ball limits himself in the main to a statement of the propositions, lemmas, &c., but occasionally he breaks in with a few words of explanation, or of historical interest.

The remaining period, ending with the year 1726, contains matter dealing with the large correspondence Newton had on the contents of his "Principia," to his revision of the whole work, the extension of some of the results, and finally to the preparations of the two later editions.

The appendices contain the correspondence between Newton and Hooke and Halley, besides some memoranda on the correspondence concerning the production of the second and third editions.

From the above brief sketch of the contents of this essay, our readers may perhaps gather some idea of the ground it covers. The author is so well known a writer on anything connected with the history of mathematics, that we need make no mention of the thoroughness of the essay, while it would be superfluous for us to add that from beginning to end it is pleasantly written, and delightful to read. Those well acquainted with the "Principia" will find much that will interest them, while those not so fully enlightened will learn much by reading through this account of the origin and history of Newton's greatest work.

WELLS ON ENGINEERING DESIGN.

Engineering Drawing and Design. By Sydney H. Wells, Wh.Sc., A.M.Inst.C.E. In Two Parts. (London: Chas. Griffin and Co., Ltd., 1893.)

THIS book is intended for the use of engineering students in schools and colleges, and as a text-book for examinations in which a knowledge of practical geometry and machine drawing is required. The author says in the preface that the chief reason which has led to its preparation is that during the time he was engaged in teaching on the engineering side of Dulwich College, he found it impossible to obtain a suitable text-book.

The work is published in two parts. Vol. i. deals with the geometrical part of the subject, but includes many references to practical questions and machinery wherein is to be found the applications of the particular geometrical construction. In the earlier treatment of this subject we find much excellent instruction for beginners, written in a clear and concise manner. The methods of construction described are all clearly illustrated, and appear to have been chosen from the best examples.

Vol. ii. deals with "machine and engine drawing and design." In the preface we find the following statement: "A student ought not to be told the sizes of bolts and nuts, or the diameter of flanges, or the details of stuffing-boxes, in drawing an engine cylinder, any more than we should expect to have to prove to him the truth of the triangle of forces, at each step in the graphical determination of the stresses in a roof truss." This statement evidently comes from the technical school view of mechanical engineering. The triangle of forces is certainly a safe assumption; but to allow one of Mr. Wells' students fresh from college to run wild in a drawing-office of an engineering works where standards are the rule, and not the exception, would be a treat not to be missed. No doubt he could turn out an excellent "technical school" drawing, but whether it would "pay" is another matter. A draughtsman generally has standards for flanges, glands, studs, &c. for an engine cylinder. Notwithstanding this, we congratulate the author on the contents of vol. ii. of his book; he has gone as far as he can to lead his students into the way of being draughtsmen; and of course this, after all, can only be accomplished—or, rather, completed—in the drawing-office of a mechanical engineer.

For the many examples and questions included in the second part we have nothing but praise; they are taken from every-day practice, and are amply elucidated. On page 183 we are told that copper pipes are made from malleable sheets, and may be as thin as $\frac{1}{16}''$. Very few copper pipes of small diameters are now used by engineers made in this way; they are usually solid drawn When iron or copper pipes require flanges, these are generally brazed to the pipes; screwed flanges with lock-nuts are seldom, if ever, used. Unions for small brass and copper pipes are usually brazed, and not screwed on the pipes, as shown in Fig. 124*d*.

Section 26, on steam engine design, is well done. It is quite refreshing to find in a text-book of this kind that questions of manufacture and shop practice are considered worthy of notice; as a rule, such details are carefully omitted—to the student's loss. The piston-rings shown in Fig. 180*a* are far too narrow for general work; and again, in Fig. 187, illustrative of a crosshead for a single slipper guide, the slipper is far too light for its work, besides being defectively attached to the crosshead. Further on, in Fig. 191, showing a connecting-rod end, surely the author would not recommend the strap to be machined out square at the corners as shown; the much-abused "practical man" would put in a radius instead, and by so doing increase the strength considerably. The brasses are also shown apart; whereas they must be tightly brought together for the type of rod end illustrated.

Beyond these few points, the two volumes are exceedingly well written, and will be of great use to students in our technical colleges. The author has taken great pains to ensure the clearness of his descriptions, and has succeeded in producing a thoroughly useful work.

N. J. LOCKYER.

THE EGYPTIAN COLLECTIONS AT CAMBRIDGE.

Catalogue of the Egyptian Collection in the Fitzwilliam Museum. By E. A. Wallis-Budge, Litt.D. (Cambridge: University Press, 1893.)

WE recently noticed at some length Dr. Wallis-Budge's book entitled "The Mummy," and mentioned that it was intended as an introduction or a supplement to his catalogue of the antiquities which belong to the University. The catalogue itself is now before us, and is, as might be expected, a scholarly piece of work. There are people who like to read catalogues; to them this volume should prove to be of greater interest even than its companion "The Mummy"; but fortunately tastes differ, and we confess that, except perhaps to a scholar of endowments equal to those of Dr. Budge himself, "The Mummy" is the better of the two. It is satisfactory, however, to remember that the Fitzwilliam collection has been duly catalogued by competent hands, and that this catalogue is now published in an accessible form, Cambridge thus taking the lead among English universities in allowing the world to know what treasures it possesses of ancient Egyptian art. This knowledge is very valuable to the student. How many of us, for example, have seen and admired at the Louvre the granite sarcophagus of Rameses III.? Yet how few of us have known till now that the lid of the same coffin is at Cambridge? When Oxford has published a catalogue like this, and when the British Museum has followed suit, the cross references from one collection to another will in themselves form an excellent guide and help to every-one who goes in seriously for this fascinating branch of oriental scholarship.

Dr. Budge begins with the granite coffins, and goes on to those of wood, which include two very complete and perfect examples: the sarcophagus of Nesi-pa-ur-shef, about B.C. 1500, and that of Pa-Kepu, about B.C. 500, which was brought home in 1869 by the Prince of Wales. Several pages are devoted to Canopic jars, and after them come boxes, figures of Ptah, as god of the dead, and ushabtiu figures, many of which are identified with kings, queens, princes, princesses, and other historical personages. A list of models of offerings follows. The sepulchral stelæ are then enumerated, the oldest of which only dates from the time of the eighteenth dynasty. Dr. Budge assigns the nineteenth dynasty as a date to the very interesting group of figures described on p. 85 as "sepulchral statues." The statues are succeeded by the inscribed scarabs, which are judiciously divided into those bearing the names of gods, those bearing the names of kings, those bearing the names of private persons, and those which are only marked with hieroglyphic devices. The collection is rich in scarabs, and only requires a better historical series to be very important. The earliest king named is Sahu-Ra, of the fifth dynasty, and there is a long hiatus between him and Menthuhetep V., and again between Menthuhetep V. and Usertsen of the twelfth dynasty. The members of the University who have visited Egypt must be many in number, and each of them, no doubt, has brought home his string of scarabs. Some of the blanks in the Fitzwilliam collection might well be filled up from such sources. It is beginning to be recognised tardily that a collection of regal scarabs stands to old Egypt as a collection of coins does to the history of any other country in the world.

HORNS AND HOOFS.

Horns and Hoofs; or, Chapters on Hoofed Animals. By R. Lydekker. (London: Horace Cox, *The Field* Office, 1893.)

"HORNS and Hoofs" will be a very useful volume to the sportsman and sporting naturalist, although we do not consider the title as particularly well selected to attract their notice. The work is, in fact, a more or less popular account of the principal mammals of the Ungulate order, which sportsmen ordinarily regard as "game." The chapters of which it consists originally appeared as articles in *The Field* and *Land and Water*. They have now been revised and put together in a connected form, and thus make a convenient volume of some four hundred pages.

Mr. Lydekker commences his book with an account of the *Bovidæ*, or "Hollow-horned Ruminants"—as they were formerly called by naturalists, which carry the same horny appendages on their heads throughout life—and gives us chapters on the oxen, and the sheep and goats, which constitute two of the chief subdivisions of this family. He then proceeds to the antelopes, which are far more numerous, and in reality should be classified in five or six groups of equivalent value to the Bovine and Ovine sections. Mr. Lydekker, however, finds it more convenient to treat of them in two divisions only, according to the countries which they inhabit, and devotes separate chapters to the antelopes of Asia and the antelopes of Africa. The members of the latter group are, as is well known, by far the more numerous, the total number of African antelopes already catalogued being nearly one hundred, whilst, as inner Africa is explored, new species are continually discovered, and even within the last few years several splendid novelties have been added to the series. Our author's account of these animals appears to be quite "up to date," the most recently described species, such as Hunter's Hartebeest from the River Tana, and Clarke's Gazelle from Somaliland, being introduced in their proper places. In some cases, however, he appears disposed rather to throw doubts upon what should be considered clearly established species. *Cobus maria* of Gray, which was also obtained by the German naturalist Henglin, and appropriately called *Cobus megaceros*, is, we can assure Mr. Lydekker, perfectly distinct from the Sunnu (*Cobus leucotis*), although found in nearly the same country. Moreover, the Sing-Sing (*Cobus unctuosus*) of West Africa is, we believe, as has been recently pointed out by Herr Matschie, quite distinct from the Defassa (*C. defassa*) of Abyssinia, and the name of the latter (being an Abyssinian, not a Latin term) should not be altered to "*defassus*"!

Mr. Lydekker next proceeds to the deer, or "Solid-horned Ruminants" of the older naturalists, the head-appendages of which should, however, be rather called "antlers," and are shed every year. These he also treats of geographically, devoting one chapter to the Asiatic and another to the South American series, which, as shown by the late Sir Victor Brooke, possess deep-seated anatomical characters that separate them from their old-world brethren. Owing to the slight differential characters which distinguish many of the (so-called) species of the latter group, and to the want of a good set of specimens in our museums, the South American deer, in spite of Sir Victor's efforts to get them straight, still remain in a great state of confusion. Any sporting naturalist who is short of work could not do better than devote himself to the collection of a good series of the neo-tropical *Cervidæ*, and try to give us a better account of them. But much as we already know of "horns and hoofs," there is still much more to be learnt even about the most familiar members of the Ungulata, and no student of the group need be in want of occupation.

Two chapters on the wild swine (*Suidæ*) and the rhinoceroses conclude Mr. Lydekker's volume, concerning which we have only to say, as in the case of the rest of his work, that all the most recent sources of information have been evidently explored for their production. Mr. Lydekker is also an excellent authority upon fossil mammals, and has availed himself of this branch of his knowledge to introduce some very useful allusions to extinct members of the various groups treated of throughout the volume. In short, we may say that "Horns and Hoofs," although specially to be recommended as a travelling companion to sportsmen and naturalists in quest of "big game," is by no means unworthy of the attention of the scientific student.