THURSDAY, OCTOBER 26, 1899.

THE INTERNATIONAL ASSOCIATION OF ACADEMIES.

OF late there has been much activity in matters which require the co-operation of scientific men of different nationalities. The International Catalogue of Scientific Literature has been the subject of several conferences. The International Meteorological Conference and the Bureau International des Poids et Mésures are samples of different types of organisations which are both numerous and useful.

The exchange of courtesies at Dover between the British and French Associations for the Advancement of Science gave another proof that cosmopolitanism is growing in strength in the scientific world, and can assert itself even when the political atmosphere is not unclouded.

A still more striking instance of the same fact will be found in the account which we give in another column of a conference at which the possibility of founding an International Association of the great Academies of the world was discussed by their representatives.

The details of the plan are, we believe, still under consideration, but enough has been done to make it practically certain that the Association will be founded, and that the Royal Society, the Academies of Science of France, of Berlin, St. Petersburg, Vienna, Rome, Washington and other similar bodies will be brought into formal relations with each other. It is, no doubt, open to pessimists to say that international meetings are now too numerous, but we venture to think that the proposal to bring about formal conferences between the principal scientific bodies in the world is most important, and that the meetings are likely to lead to more permanent results than do gatherings (also useful in their way) from which the picnic element is not altogether eliminated.

On the other hand, an Association of Academies will be a more flexible instrument for good than are international organisations appointed for specific purposes, and composed either of persons named by the Governments of the countries represented, or of officials controlling national observatories.

The Committee of the Bureau International des Poids et Mésures in Paris and the Geodetic Conference at Berlin are examples of bodies which are entrusted with strictly defined duties, and cannot travel outside the lines laid down for them by their respective Governments. A union of Academies would, however, bring about the meeting at stated intervals of representatives of science, who would not be fettered by the official ties which must necessarily restrict the action of Government nominees. It would thus be possible for the associated Academies to discuss questions connected with any branch of science which might in their opinion call for international co-operation, and if they decided that such action was desirable, to take steps to call the attention of the scientific world or of the various Governments to the necessity for united action.

The Association would, in fact, enjoy the same freedom as the Council of the Royal Society, while it would be able to bring to bear on any question the mature opinion of representatives of the whole scientific world.

It is obvious that an Institution founded on these lines may become of the very first importance, and may play the part of an international parliament of science. Whether or no such a hopeful forecast is realised, it cannot but be useful that the centres of scientific organisation in different countries should themselves be organised, and should be united—not merely by common interests, or by the bonds of friendship which have been established between many of their members—but by formal links which will enable them to take united action when such action is required.

As some of the foreign Academies are concerned with literature and philosophy as well as with natural science the Association will be based upon the same lines. The two sections into which it will be divided will, however, be almost entirely independent, and no serious difficulty need be anticipated on this score. It is, however, curious that though both of the great Anglo-Saxon nations possess important societies concerned with the cultivation of different branches of literature, history or philosophy, neither of them has developed an institution the breadth of whose aims would warrant its inclusion in a list of Academies of literature. It will be unfortunate if this fact makes the literary section of the new Association less truly representative than that which will be concerned with natural science.

"An academy quite like the French Academy . . . we shall hardly have, and perhaps we ought not to wish to have it," said Matthew Arnold, but it will be interesting to see if the foundation of an International Association of Academies leads to a rearrangement of existing organisations which might give us in England something corresponding to the "Académie des Inscriptions et Belles-Lettres," or to the "Académie des Sciences Morales et Politiques."

A PIONEER IN TELEGRAPHY.

The Life Story of the late Sir Charles Tilston Bright; with which is incorporated the Story of the Atlantic Cable and the First Telegraph to India and the Colonies. By his Brother, Edward Brailsford Bright, and his Son, Charles Bright. Pp. xix + 506, and xi + 701. (Westminster: A. Constable and Co.)

TWO books have recently appeared dealing with telegraphy from shore to shore, the one on "Submarine Telegraphs" from the pen of Mr. Charles Bright alone, the other the two-volume treatise now under review. Both are somewhat lengthy, the former because the description of "Submarine Telegraphs" was so much bound up with details concerning the life of Sir Charles Bright, and the latter because to the "Life Story of the late Sir Charles Bright" has been added so much about the history of submarine telegraphy.

Leaving the accounts of the ancestors of this family which are given in rather bewildering detail, we come to the boyhood and youth of the two brothers Charles and Edward. Charles at fifteen, and Edward at sixteen, entered the service of the Electric Telegraph Company soon after its formation in 1847, and started on their careers as inventors. In 1849 they devised a method for enabling the position of a fault on a telegraph line to be ascertained electrically by the use of resistance coils. In two more years they both left the Electric Telegraph Company, and joined other companies which had started as rivals of this company and of one another, viz. the British Telegraph Company, to which Charles became the assistant engineer, and the Magnetic Telegraph Company, with which Edward associated himself.

But it was the ingenuity and energy which the subject of this memoir displayed in laying the telegraph wires under the streets of Manchester that first brought him into prominent notice. In one night the many gangs of navvies under his superintendence had the streets up, the lower halves of cast iron tubes laid down, gutta-percha covered telegraph wires (wrapped into ropes with tarred yarn) unwound off drums into this iron channel, the two halves of the tubes placed in position, the trench filled up, and the pavement laid down before the inhabitants were out of their beds in the morning.

This account reads like that of a cutting-out expedition of a young Nelson, or a surprise attack of a youthful Wellington, and such an exploit hardly seems possible in the case of the County Council scholar of the modern day, full, it is true, of facts and knowledge, but who has devoted so much attention to learning off what other people have thought out, that he has never had time to find out what he thinks himself, and the bent of whose activity seems to be directed to begging his numerous teachers to give him a sheaf of testimonials and to furnish him with a post.

We can also recommend the study of this exploit of the nineteen-year old Bright to the notice of the local authorities of London from another point of view. In entire oblivion apparently of the fact that the traffic in our streets is not only as great as it was half a century ago, but has become one of the most perplexing difficulties of the present time, and probably in ignorance also of the fact that the developments that have taken place during the past ten years in electric lighting have supplied facilities for carrying on night work in the streets such as were not dreamt of fifty years ago, Bumble still lays long lines of pipes under Fleet Street, Holborn, and the Strand, on what may be called the one man, one boy and a donkey-cart method. And further, since it is generally during the height of the London season that the streets remain broken up for days at a time, we presume that the local authorities are labouring under some delusion that the navvy periodically spends his autumn away from town—say in Switzerland—and is, therefore, only available as an obstructionist about the month of May.

The cable to Ireland having been successfully laid in 1853, attention began to be turned to connecting Great Britain with America. The Atlantic Telegraph Company was consequently formed, but without advertisements or a board of directors, without brokers, commissions, executive officers, promotion money, or even a prospectus. What a striking contrast to the present philanthropic efforts of the "vendor" to benefit the world, and the anxiety of the "scientific expert" to give wide publicity to the extraordinary efficiency of everything that is brought to his notice—professionally.

Considerable vagueness existed at that period as to what the speed of sending messages through a submarine cable really depended on; the memoir states that Sir Charles Bright advocated the employment of a thick copper conductor, weighing 3½ cwt. per mile, surrounded by a coating of gutta-percha having the same weight, but that Faraday, Morse and Whitehouse did not understand the problem properly, and therefore that they opposed Bright's proposal to use a large conductor for the reason that the electric capacity of the cable would be thereby made large, and as, therefore, a large amount of electricity would be required to charge it at each signal the speed would be slow. Lord Kelvin in his Royal Society paper pointed out that the retardation depended neither on the capacity alone nor on the resistance of the conductor alone, but on the product of the two; and so made the whole theory clear—at least made it clear to those who were able to appreciate what a Fourier series could possibly have to do with telegraphing to America.

But economical counsels prevailed, and the copper conductor of the actual Atlantic cable weighed only 107 lbs. a mile, and the gutta-percha coating 261.

The account of the laying of the first Atlantic cable is stirring, thanks partly to the long extracts from the graphic and exciting descriptions which were published by Mr. Nicholas Woods in the *Times*. Numerous were the attempts to lay this cable, and, although they were at last crowned with success—in so far that an Atlantic cable was completed in August 1858, and several messages were actually sent through it—this cable had but a very brief life, one of only three short months in fact.

Numerous arguments are adduced to prove that the causes which led to its break-down all arose from one reason, viz. that the directors did not take the advice of Sir Charles Bright. But, although it is undoubtedly true that the subject of the memoir was an exceptionally able, enthusiastic and energetic man, the contention that if only his advice had been followed the 1858 Atlantic cable would have been a permanent success is not quite so obvious.

For example the use of a powerful induction coil to work a long cable, which is so properly denounced in the body of the book itself, and to which the speedy death of the first Atlantic cable was undoubtedly, at any rate in part, due, was actually resorted to by Sir Charles in his experiments on ten separate lengths of underground wire, joined up to make a total length of two thousand miles, as described in his remarks at the Institution of Civil Engineers in 1857, and quoted in Appendix v. of the book under review. And the successful results obtained with these induction coils "thirty-six inches in length and excited by a powerful Grove battery of fifty pint cells," were advanced as a reason why "he could not see what there was to prevent the working, successfully, through a direct line of two thousand miles" such as an Atlantic cable.

Again, the folly of the Atlantic Telegraph Company in not adopting the larger dimensions which Sir Charles Bright desired to give to the first Atlantic cable is not so evident, since the 1865 cable, which possessed these dimensions, had to be abandoned—broken, after many unsuccessful attempts had been made to lay it—and in the following year, some months after it had been recovered and completed, both it and the new 1866 cable broke, while one of them broke again the following year.

The fact is that to construct an Atlantic cable at all in those days was a very courageous thing to do; to lay it successfully, even with many failures, evinced a faith and confidence in engineering skill and a dogged spirit of determination that make one proud of the Anglo-Saxon race. To every one who took a prominent part in the enterprise, as certainly did Sir Charles Bright, all honour is due as well as the thanks, not only of his contemporaries, but of all who have followed him.

But we are inclined to think that the authors of this memoir would have been well advised had they not allowed their reverential memory for the brother of the one and the father of the other to lead them to adopt the painter's only method of representing a bright light, viz. by intentionally throwing the rest of the picture into shade.

Volume ii. deals with the telegraph to India, Sir Charles' parliamentary life, the West Indian cables, Sir Charles' work in connection with mining, fire alarms, telephony, electric lighting, the Paris Electrical Exhibition of 1881, the Institution of Electrical Engineers, Freemasonry, and concludes with various appendices.

This life-story is distinctly interesting, but its interest would have been even greater had the matter been compressed into about half, or at any rate into not more than two-thirds, the space. Before a second edition appears we would suggest that such scientific crudities as the following should be altered:—"A current which was estimated by the experts to amount to about 2000 volts." "In the absence of a determinate unit of inductive capacity or quantity of electricity condensers were employed for the first time." "When electricity passes through this surrounding coil of wire, the magnet and mirror take up a position of equilibrium between the elastic force of the silk and the deflecting force of the current. . . . The magnet is artificially brought back to zero with great precision after each signal by the use of an adjustable controlling magnet."

OUR BOOK SHELF.

The Maintenance of Solar Energy. By F.R.A.S. Pp. 20. (London: The Southern Publishing Co., Ltd., 1899.)

THE author of this short essay is not satisfied with the current ideas as to the maintenance of solar energy, but believes his new views tend to remove much of the difficulty. So far as can be judged by these "preliminary notes," however, the theory advanced is one which is not likely to convince any one but its author. Interplanetary water vapour and the periodical indulgence of the sun in cometary vapour baths appear to play an important part, the idea being that as a result of their action the radiant forces of the sun are confined within the limits of the solar system. The recurring absorption of the planets by the sun and subsequent disruption into new systems are other features of a theory which has its principal strength in the fact that there are no means of testing its chief teachings. The author's name does not appear on the title-page, but the preface is signed by J. H. Brown.

Official Report of the National Poultry Conference held at Reading in July 1899. Edited by the Honorary Secretaries, Edward Brown, F.L.S., and F. H. Wright, F.S.A.A. Pp. xvi + 138.

THE conference of which this is a report was the first of its kind held in this country, and its success should lead to other similar meetings. The report shows that most of the papers were of a scientific character, and its publication should extend the knowledge of the principles which lead to successful poultry-farming. Among the subjects dealt with are: the science and practice of farm poultry keeping, the parasitic diseases of poultry, and the assistance afforded by science in the production of eggs and poultry. There will be hope for British agriculture when the spirit which pervades these papers guides the operations of all who are concerned with rural industries.

The Story of Ice in the Present and Past. By W. A. Brend. Pp. 228. (London: George Newnes, Ltd., 1899.)

AN instructive addition to the "Library of Useful Stories," containing a clearly-written account of the physical properties and geological operations of ice. General readers should find the volume interesting. We notice that the cavities formed by glacier mills are termed "potholes or giant's kettles"; but the former term ought to be restricted to the circular holes found in the beds of streams.

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.*]

Effect of Vibration on a Level Bubble.

I HAVE never seen any notice of this phenomenon, but it is sufficiently curious to be worth describing.

I had fitted on a bicycle a small level with a radius of curvature of a foot, in order to note gradients without dismounting. In general this answered very well, and the gradients could be satisfactorily measured with an accuracy of about 1 per cent., but when going over certain classes of rough road (*e.g.* granite paving), the roughnesses of which had a definite pitch, it was noticed that though the road might be level, the bubble would at certain speeds indicate gradients as steep as one in eight or one in six, and remain steadily in such positions as long as the speed and character of the road remained constant. It seemed a matter of chance whether the bubble moved so as to indicate an up or a down gradient.

The explanation is to be found in the coincidence of a natural period of the bubble, due to the surface tension of the fluid, and the interval which elapses between successive encounters of the bicycle wheel with the roughnesses of the road.

Owing to the level being at a certain height above the ground (it was attached to the upper tube of the frame), any pitching of the bicycle, such as is caused by going over rough ground, gives a backward and forward motion to the frame in addition to the general onward movement.

We may suppose, for the sake of simplicity, that this backward and forward motion is a simple harmonic.

When a level is subjected to a harmonic displacement parallel to the mean direction of the tube, the bubble will endeavour at each instant to place itself at that part of the tube where the tangent is at right angles to the resultant of gravity and the imposed acceleration. Thus the bubble tends to move relatively to the tube in the direction of the displacement of the latter, and would always occupy its true position with regard to the resultant if its motion under the variable force was quick enough. The motion of the bubble, however, is very slow compared with that required to bring about this result; but although the forces which act on the bubble have not time to move it far in each period, they do deform it, and the deformation may become large if the imposed force has the same frequency as any of the natural vibrations of the bubble.

When the bubble is long, as in an ordinary level, the result when such a coincidence is reached is that the long bubble is broken up into a number of small ones, but in the bicycle level the bubble was small and nearly spherical.

The slowest natural vibration which a spherical bubble is capable of is that in which it becomes alternately a prolate and oblate spheroid.

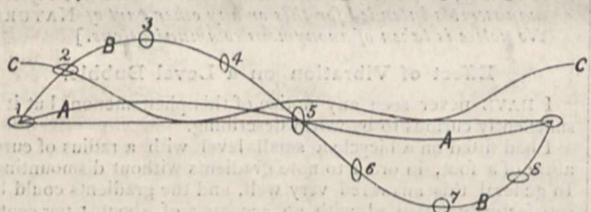
It would take too long to enter in detail into the character of the deforming forces acting on the bubble. They are of two kinds, one depending on the acceleration and the other on the velocity. The former tends to make the bubble egg-shaped (*i.e.* big at one end and small at the other) to a degree proportionate to the acceleration; the latter involves the ratio of the cross section of the bubble and tube, and tends to make the bubble oblate as the velocity increases.

When the impressed motion has the same period as the bubble, the latter will pass through its zero position in opposite phases. Thus, if in moving forwards it is an oblate spheroid as it passes through the zero, it will be prolate half a period later when returning backwards through the same position, but both the deforming force and resistance to motion through the fluid which the bubble experiences when prolate are less than when it is oblate, so that there is a balance in favour of the oblate deformation, which will tend to increase and perpetuate a vibration once started.

Since the resistance experienced by the prolate form is less than oblate resistance, the excursion of the bubble will be greater in the first case than the last, with the result that in time it will move to such a position that the slope of the tube there supplies a force sufficient to balance the difference of resistance met with in moving in opposite directions.

In the accompanying diagram the direction of the level tube is supposed to be at right angles to the abscissa axis, which represents the time of one oscillation.

AA displacement of level tube; BB displacement of bubble relatively to the tube; CC deforming force depending on the



velocity; 1, 2, 3, &c., the forms assumed by the bubble at various phases.

There is some particular ratio between the diameters of the bubble and tube, and some absolute diameter of the tube, depending on the surface tension and density of the fluid, which gives the maximum displacement, but even an approximate analytical solution of the problem would present great difficulties.

In the level experimented on, the surface tension of the fluid employed was 27 (in C.G.S.) and density ·88.

The radius of the bubble was ·142 cm. and that of the tube ·23 cm. (rough measurements).

A spherical bubble of the radius given if surrounded by an unlimited quantity of fluid of this surface tension and density would have for the frequency of its slowest natural vibration 120 per second nearly (see Lamb, "Hydrodynamics," p. 463), but in the case under consideration the small distance between the sides of the bubble and tube must greatly diminish the frequency of this form of vibration.

By experiment it was found that the greatest displacement occurred with a frequency between 40 and 50 per second, the bubble then being driven to the ends of the tube where the slope was about one in five. A. MALLOCK.

3, Victoria Street, October 3.

Rural Education.

THE Countess of Warwick and Prof. Meldola are entitled to all praise for their zeal in establishing the School of Science at Bigods, to which reference was made in your issue of October 5. There should, however, be some recognition of the similar work done by others in purely rural districts. At Bruton, a village in Somersetshire, the success of such a school has been quite phenomenal. Sexey's Trade School, as it is called, owes its inception to Mr. Henry Hobhouse, M.P., and was founded a few years ago out of the old endowments of Sexey's Hospital under a scheme of the Charity Commissioners, with aid from the Somerset County Council. Recently I had an opportunity of seeing the school, and could not sufficiently admire the excellence of what is done there. The buildings consist of a master's house, large schoolroom and lecture-rooms, well-equipped physics and chemical laboratories, wood and metal workshops, gymnasium, &c., with about two and a half acres of garden and playground attached. Besides instruction in the ordinary subjects of a higher primary or secondary school, the boys in the upper division (Classes II. to V.) are taught magnetism, electricity, chemistry, mechanics, manual work in cardboard, wood and metal, mensuration, French, botany and bookkeeping, and the instruction in technical subjects is throughout of a *practical* nature, being given in the garden, field, and workshops, as well as in the class-room. Outdoor lessons are given in land measuring. Visits are occasionally paid to farms in the neighbourhood to inspect the stock, implements, buildings and crops. Botanical walks are taken at intervals in order to study plants in their natural habits, and the boys are encouraged to make collections of botanical and other specimens.

Since 1896 the school has been organised as a School of Science, and through the courtesy of the headmaster, Mr. Knight, I am able to place the following details before your readers. The fees for tuition are 4*l.* and for boarding 20*l.* per annum. The school has been accepted by the Somerset and Wilts County Councils as one of those at which junior and intermediate county scholars may attend. There are 103 boys at the school, of whom 25 are the sons of farmers, 20 of artizans, and 32 of small tradesmen. Of those who have left the school 34 have taken to farming as an occupation. From the forty-fifth Report of the Science and Art Department it appears that in 1897 the school presented 63 pupils for examination. The grant earned was 384*l.*, being an average of 6*l.* 2*s.* per head. The High School at Middlesbrough stood next on the list with an average of 5*l.* 13*s.* per head, and the general average for the 143 organised Science Schools in Great Britain was 3*l.* 9*s.* 6*d.* Such an experience as this ought to be of the greatest encouragement to those who are really anxious for the improvement of rural education, and the facts cannot be too widely known. This school differs from the one at Bigods in that it is only for boys; but a school is now being erected in the immediate neighbourhood to provide a modern education for girls, corresponding as far as possible with that provided for the boys. JOHN C. MEDD.

Stratton, near Cirencester, October 15.

THE good work being done at Sexey's Trade School is of course well known to all who have interested themselves in rural education. Readers of NATURE will no doubt be glad to have Mr. Medd's independent testimony, and more particularly the detailed statement of figures concerning grants and fees. At the present time, when the subject of rural education is so very much before the public, it would, however, be of the greatest assistance to those who are engaged in carrying on this work if Mr. Medd could supply more detailed information concerning the aid which the County Council has given and how this assistance has been rendered; whether in the form of grants for building and equipment or for maintenance of staff, or both. Also what proportion of the initial cost of foundation as a School of Science was contributed by the Somersetshire County Council? In the present state of rural education one cannot help feeling that the whole future success of these schools is very largely dependent on the constitution of the Technical Instruction Committees of the County Councils—especially in those cases where the County Council has become recognised as the central authority. Any information, therefore, that can be given on these administrative points, either with respect to Sexey's or any similarly constituted school, would be most opportune. In the case of our school at Bigods, the initial cost of foundation and conversion into a School of Science has been mainly borne by Lady Warwick. The Essex County Council, as regards maintenance of staff, have put us on the same footing as the endowed schools in the county by granting 100*l.* annually. R. MELDOLA.

ON THE DISTRIBUTION OF THE VARIOUS CHEMICAL GROUPS OF STARS.[1]

SOME few years ago it was my duty to give a course of lectures here relating to the sun's place in nature. I attempted to give an idea of the relation of the sun, as to age and temperature, to other stars, and also its relation to bodies supposed to be of a different order altogether.

Since that lecture was delivered our knowledge on this and allied subjects has advanced with giant strides. We now know, thanks to spectrum analysis, the principles of which I then explained, a great deal of the chemistry of the stars, so much that we can now classify them into groups, defining those groups by the chemical elements involved in each. I shall not bring before you to-night the detailed classification of these bodies, but shall, for the purposes of this lecture, ask you to consider the four following kinds only:

Highest temperature.

Gaseous stars { Proto-hydrogen stars. / Cleveite-gas stars.
Proto-metallic stars.
Metallic stars.
Stars with fluted spectra.

Lowest temperature.

The table almost explains itself: I may add that by "proto-metallic" stars I mean those stars in the spectra of which the metals we know here are chiefly represented by lines—the so-called "enhanced-lines"—we can only obtain here by using high-tension electricity, and there are other evidences which show that these stars are hotter than the metallic ones, while they, in their turn, are cooler than the gaseous stars. In discussing the work of other observers I have as far as possible transposed the different notations employed into the chemical one given above.

In relation to the sun's place we had a great many comparisons to make with different stars quite independently of their position in space. I propose now to touch upon a still more general inquiry to consider the distribution of all stars in space, not in relation to their magnitudes, but in relation to their chemistry.

It is obvious that we are among the first from the beginning of the world who have been able to do this, because formerly the chemistry of these celestial bodies was entirely lacking. I think, therefore, you will agree that it is a very important thing, now that we have the chemistry, to inquire into the distribution of the various chemical conditions in the different parts of the universe in which our lot is cast. For that purpose, I will deal with the stars as generally as I can, considering only the wider division into the gaseous stars, the proto-metallic stars, that is to say, the stars represented by the enhanced lines, then the metallic stars in which we are dealing with arc lines, and then the metallic fluting stars and the carbon fluting stars. As star-life begins with nebula and meteoritic swarms, it ends with dark stars which it is possible may be very numerous in space. How many there are we do not know, because we cannot see them; but there are reasons for supposing that there is a very considerable number.

We have only to deal with the masses of matter in space which are visible, and it is obvious that any inquiry into the distribution of the chemical conditionings, as revealed by spectra, of these masses must be preceded by an inquiry into the distribution of these masses considered merely as masses and quite independent of chemistry.

This work has already occupied the attention of many eminent astronomers, and I will begin by placing the results of their labours before you as shortly as I can.

I call your attention to the Milky Way. If you have seen the Milky Way from a high mountainous country, as I have done, you will acknowledge what a very wonderful thing it is; I was most struck with the Milky Way when I was in the Rocky Mountains some years ago. It was not merely the pale milky belt we generally see running across the sky, but it had lights, shades, shadows, brightnesses and dimnesses; it was full of the most marvellous details. I have seen it, I am bound to say, just as well on the coast of Kent, but not often. You want an extremely fine sky to see the Milky Way properly; but, at all events, whether you have seen it well or ill, all of you, I am sure, are familiar more or less with it. What is it? It is a bright belt encircling the heavens; its position with regard to the equator of the earth, and the equatorial plane extended to the stars, I can show you roughly by means of a glass globe. Those who are familiar with Dante know that the old view of the heavens was that the earth was immovable in the

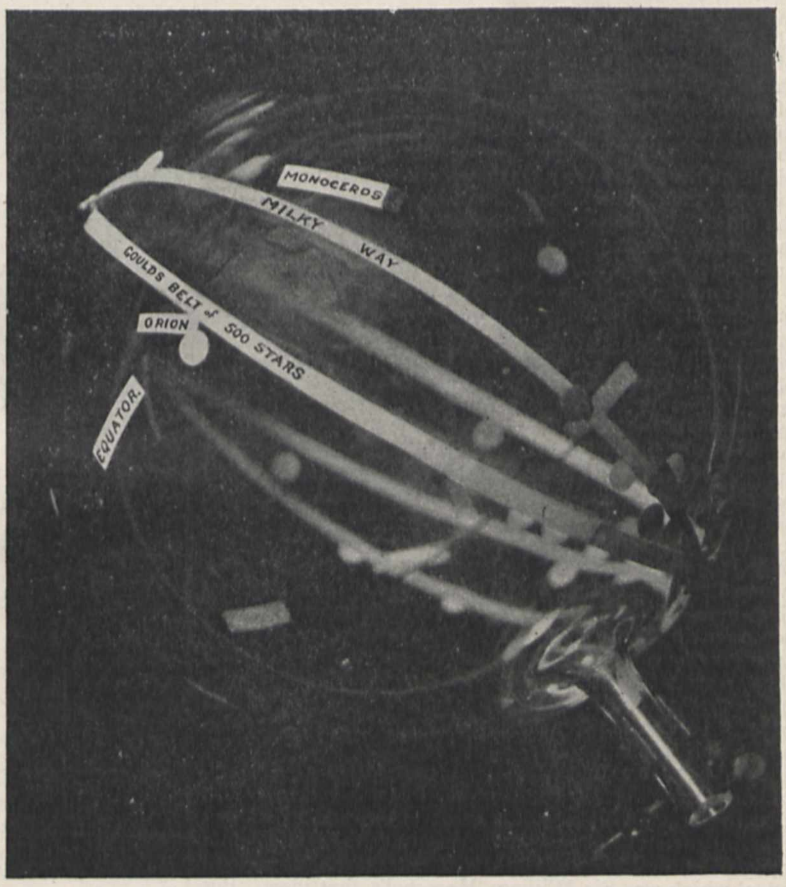


FIG. 1.—Photograph of a glass globe showing the relation of the Milky Way to the Equator an to Gould's belt of stars.

[1] A Lecture to Working Men, delivered at the Museum of Practical Geology, on April 10, by Prof. Sir Norman Lockyer, K.C.B., F.R.S.

centre; that there were several heavens round it: the heaven of the moon, the heaven of Venus, of Mars, and so on, till at last there was a heaven of the stars, a crystalline sphere to which the stars were fixed like golden nails. Let the glass globe represent this crystalline sphere.

The Milky Way is a great circle inclined, at an angle of about 62°, to the earth's equator or to the equatorial plane extending to the stars. We know nothing, of course, of the reason for that angle of 62°, but it has its importance, because not only must the belt cross the equator at two opposite points, as it does in two opposite constellations, Aquila and Monoceros, but the poles of the Milky Way must lie at the points of greatest distance from the junction with the equator, in certain constellations. These are Coma Berenices and Sculptor, and the position of the N. galactic pole, as the pole of the Milky Way is called, is in R.A. 12h. 40m. Dec. + 28°. Now, although the Milky Way looks very unlike the other parts of the heavens, we have known since the time of Galileo that the difference arises from the fact that it is composed of a tremendous multitude of stars; and this is why I have drawn attention to it, a very large percentage of the masses of matter which compose our system lies in the plane of the Milky Way. It does not merely represent a fiery or igneous fluid, as different schools thought it did in the old days. So far as our opera-glasses and telescopes indicate to us, we are in presence of an innumerable multitude of stars. When, however, we come to look at it a little more closely, we find that from two points in it branches are thrown out, so that over some part of its orbit, so to speak, it is double; there is a distinct doubling of the Milky Way along a part of its length. But in spite of that, the middle line of the galaxy or the Milky Way is really not distinguishable from a great circle, as was formerly supposed. The great rift which separates these two parts of it begins near a star in the southern hemisphere, α Centauri, and it continues for more than six hours in right ascension until the two branches meet again in the constellation Cygnus, which is well within our ken in the northern heavens. The distance apart of the middle lines of these two components of the Milky Way where the split is most obvious is something like 17°, so that, in addition to the angle of 62° from the ecliptic, in some part of the Milky Way, there is another offshoot springing out of it at an angle of something like 17°. The regions of greater brilliancy correspond approximately to the places where the branches intersect each other. In short, there are sundry indications that the whole phenomena of the Milky Way may become simplified by treating it as the resultant of two superimposed galaxies. The general view till recently was that the Milky Way is not a great circle, because it was thought the sun was not situated in its plane. The whole mass of stars was likened to a millstone split along one edge, which was Sir William Herschel's first idea. But the recent work, chiefly of Gould in Argentina, has shown that it practically is a great circle. However that may be, in one part of the heavens this wonderful Milky Way appears as a single, very irregular stream, and in another part it appears to be duplicated.

It is impossible in this short course of lectures to attempt to give anything like an historical statement of the growth of our knowledge of the Milky Way. I can only refer you to the Milky Way itself; and the next time any of you have an opportunity of seeing it, just look at the wonderful majesty and complexity of it. We find in it indications of delicate markings going out into space, apparently coming back strengthened, of streams in all directions, of clusters clinging to those streams, and so on. In other parts it is curdled, which is the only term which I can use to express my meaning. In another part we may find it absolutely free from any important stars; in another we may find it mixed with obvious nebula; and in another we may find it mixed, not only with obvious nebula, but with a great number of bright-line stars involved, not only in the Milky Way, but in the nebula itself.

We have now, fortunately for science, priceless photographs of these different regions. One will give us an idea of the enormous number of stars in some parts; another one of the streams of nebulous matter which are seen in the Milky Way from region to region. Again we find a regular river of nebulous matter rushing among thousands of stars. In some the galaxy seems to tie itself in knots. There is an individuality in almost every part of it, which we can study on our photographic plates; practically there are no two parts alike. Others again bring before us the curdled appearance which is visible in different regions, and finally the connection of the infinite number of stars with obvious nebulous matter. In this way, then, we are enabled to form an idea of the general conditioning of things as we approach the Milky Way.

The next important point is that the enormous increase of stars in the Milky Way is not limited to the plane itself, but that there is really a gradual increase from the poles of the Milky Way, where we get the smallest number of stars. It is not very easy to bring together all the information, for the reason that different observers give different measures; they take different units for the space they have determined to be occupied by stars from the pole towards the galactic plane; and also the number of stars in the northern hemisphere is not the same as the number in the southern hemisphere. But roughly speaking we may say, if we represent the number of stars at the galactic pole by four, the number of stars in the galactic plane will be about fifty-four.

The following table will show the gradual increase in the number of stars from the pole to the plane, as seen by the Herschels with a reflecting telescope of eighteen inches aperture and twenty feet focal length:—[1]

Galactic polar distance.	Average number of stars per field of 15'	
	Northern.	Southern.
° ° 0–15	4·32	6·05
15–30	5·42	6·62
30–45	8·21	9·08
45–60	13·61	13·49
60–75	24·09	26·29
75–90	53·43	59·06

A consideration of the distribution of stars in Right Ascension between declinations 15° N. and 15° S. led Struve to the conclusion that there are well marked maxima in R.A. 6h. 40m. and 18h. 40m., and minima in R.A. 1h. 30m. and 13h. 30m.; he remarks that the maxima fall exactly on the position of the Milky Way in the equator, and further states that "the appearance of the close assemblage of stars or condensation, is closely connected with the nature of the Milky Way, or that this condensation, and the appearance of the Milky Way, are identical phenomena."

Although the Milky Way dominates the distribution of stars, and especially of the fainter stars, it does not appear to be the only ring of stars with which we have to do. Sir John Herschel traced a zone of bright stars in the southern hemisphere, which he thought to be the projection of a subordinate shoot or stratum. That was the first glimpse of a new discovery, which was subsequently established by Dr. Gould in his work in the southern hemisphere at Cordova. He found that there was a stream of bright stars to be traced through the entire circuit of the heavens, forming a great circle as well de-

[1] *Outlines of Astronomy*, Herschel, pp. 535, 536.

fined as that of the galaxy itself, which it crossed at an angle of about 25°.

Gould, while in the southern hemisphere, had no difficulty in observing that along this circle, which we may call the Star-way, in opposition to the Milky Way, most of the brighter stars in the southern heavens lie.

When he subsequently came home he made it a point of study to see whether he could continue this line of bright stars among the northern hemisphere, and he found no difficulty. So that we may now say that the existence of this supplementary Star-way, indicated by the line of extremely bright stars, is beyond all question.

I quote the following from what Gould has written on this subject.[1]

"Few celestial phenomena are more palpable there than the existence of a stream or belt of bright stars, including *Canopus*, *Sirius*, and *Aldebaran*, together with the most brilliant ones in *Carina*, *Puppis*, *Columba*, *Canis Major*, *Orion*, &c., and skirting the Milky Way on its preceding side. When the opposite half of the galaxy came into view, it was almost equally manifest that the same is true there also, the bright stars likewise fringing it on the preceding side, and forming a stream which diverging from the Milky Way at the stars α and β *Centauri*, comprises the constellation *Lupus*, and a great part of *Scorpio*, and extends onward through *Ophiuchus* towards *Lyra*. Thus a great circle or zone of bright stars seems to gird the sky intersecting with the Milky Way at the Southern Cross, and manifest at all seasons, although far more conspicuous upon the *Orion* side than on the other. Upon my return to the North, I sought immediately for the northern place of intersection; and although the phenomenon is by far less clearly perceptible in this hemisphere, I found no difficulty in recognising the node in the constellation *Cassiopeia*, which is diametrically opposite to *Crux*. Indeed it is easy to fix the right ascension of the northern node at about 0h. 50m., and that of the southern one at 12h. 50m.; the declination in each case about 60°, so that these nodes are very close to the points at which the Milky Way approaches most nearly to the poles. The inclination of this stream to the Milky Way is about 25°, the Pleiades occupying a position midway between the nodes."

Gould also had no difficulty in showing that the group of the fixed stars to which I have just referred, at all events of fixed stars brighter than the fourth magnitude, is more symmetrical in relation to this new star line than to the Milky Way itself, and that the abundance of bright stars in any region of the sky is greater as the distance from this new star line becomes less. Practically five hundred of the brightest stars can be brought together into a cluster, independent of the Milky Way altogether—a cluster he points out of somewhat flattened and bifid form.

Not only do we find that the stars are very much larger in number near the Milky Way than elsewhere, but that the same thing happens with regard to the planetary nebulæ. Nebulæ generally, I am sorry to say, I cannot profess to discuss with any advantage, because there are very many bodies classed as nebulæ in the different catalogues about which we know absolutely nothing as to their physical nature. It will be remembered that many years ago the question of the real existence of nebulous matter in space was rendered very difficult by the fact that the larger telescopes, which were then being made by Lord Rosse, brought before us a great number of clusters, the stars of which were so close together that they seemed to form a nebulous patch, whereas on a finer night or with a better instrument we were able to see that we were simply dealing with distant clusters. I do not propose, therefore, to say anything about nebulæ generally, but to call attention to those points about which we can be most certain.

[1] *Amer. Jour. Sci.*, viii. p. 332.

We do know that, not only do we find stars increasing in number as the Milky Way is approached, but the undoubted star clusters also increase towards the Milky Way in a marvellous manner.

Bauschinger[1] (1889) in a review of Dr. Dreyer's New General Catalogue (7840 objects) discussed the distribution of different classes of objects and found that star clusters, by which he means of course resolved clusters, and planetary nebulæ congregate in and near the galaxy.

Mr. Sydney Waters some four years later, in 1893, brought together the nebulæ and the star clusters for us, and I propose to show the very important maps which he drew. He indicates a star cluster by a cross, and nebulæ by round dots. Practically the obvious star clusters are limited to the Milky Way. That is a very admirable way of bringing the knowledge with regard to any one of these distinct groups of stars before us, and it shows us in a most unmistakable manner that the star clusters, like the planetary nebulæ and stars generally, are very much more numerous in the plane of the Milky Way than they are in any other part of the heavens.

It is striking to note the fidelity with which the clusters follow, not only the main track of the Milky May, but also its convolutions and streams, while the remarkable avoidance of the galaxy by the nebulæ, excluding the planetary nebulæ, is obvious, indeed, it was remarked upon by Sir Wm. Herschel.

We have seen, then, that we have the greatest number of stars congregating in the plane of the Milky Way, the greatest number of planetary nebulæ and the greatest number of star clusters. We have next to consider whether any particular kind of a star congregates in the Milky Way or avoids it. In that way we shall be able to see the importance of this new chemical touch, which is now possible to us in our survey of the heavens.

The first attempt at such an inquiry as this was made in 1884 by Dunér,[2] who had made himself famous by his admirable observations on two different classes of stars—those which I have referred to as being defined by carbon flutings in one case and metallic flutings in the other. His work was practically the only research on the carbon stars—the stars, that is, with carbon flutings. He was, naturally, anxious to see how they were distributed, and he gives the number of these stars in varying parts of the heavens in relation to the Milky Way. He found that the numbers increased towards the Milky Way. The table I give will show the general result at which he arrived. We had, as we saw in the case of the ordinary stars, a very rapid progression in number from the pole of the Milky Way to the plane; we had three stars at the pole when we had fifty-three in the plane.

Dist. from galactic pole.	Number.	Mean mag.
° ° 0-35	3	6·6
35-60	8	6·6
60-70	8	7·2
70-80	13	7·4
80-90	29	8·3

Dunér found, with regard to his carbon stars, that there was distinctly an increase from the pole towards the plane, but we observe that the rate of increase was very much less in this case; so that, starting with three at the pole, he only found twenty-nine in the plane. Although then it was true that the number of stars did increase towards the Milky Way, they did not increase so rapidly as the stars taken as a whole; still, from his observations, we are justified in stating that

[1] *V.J.S. Ast. Ges.*, xxiv. p. 43.

[2] "Étoiles de la troisème Classe," p. 126.

there is an increase as we approach the plane of the Milky Way. They are, therefore, not limited to the plane. Now we know that these stars are the moribund stars, the stars just disappearing, the stars whose light is waning; so that soon after the carbon stage they exist in the heavens as dark stars, and we can only know their existence by their gravitational effect upon other stars which are self-luminous. It is also to be borne in mind that these stars, just because they are in their waning

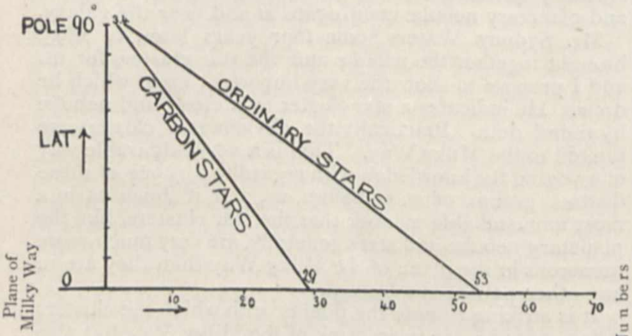


FIG. 2.—Comparison of relative numbers of stars generally and carbon stars.

stage, are very faint; so that the information we are able to get with regard to them may possibly be information concerning their distribution in parts of space not very far distant from that which we ourselves occupy.

That was in 1884. In 1891 Prof. Pickering, when he found that he had collected something like 10,000 stars in the Draper catalogue, began to consider their distribution in different parts of space in relation to the then classification, which was practically a classification founded on hieroglyphics, since we knew very little about the chemistry of the different bodies at that time.

He found that the Milky Way was due to an aggregation of white stars, by which he meant, as we now know, very hot stars, and the hottest of them, that is the gaseous ones, exist more obviously in the Milky Way than do the others. The proportional number of proto-metallic stars in the Milky Way was greater for the fainter stars than for the brighter ones of this kind, and that at once suggests a possibility that in the Milky Way itself there is a something which absorbs light; so that the apparently brightest stars are not actually the brightest, but are more luminous because they have not suffered this absorption, and that those which have suffered this absorption may be very much further away from us than the others of a similar chemistry. He also arrived at this extremely important conclusion, namely, that the metallic stars, that is, stars like our sun, stars more or less in their old age, had no preference for the Milky Way at all, but are equally distributed all over the sky. With regard to the group of stars known by metallic flutings in their spectra, he has no information to give us any more than Dunér had, for the reason that their number is small and they have not yet been completely studied.

Only last year this inquiry was carried a stage further by Mr. McClean, who not only photographed a considerable number of stellar spectra in the northern hemisphere, but subsequently went to the Cape of Good Hope in order to complete the story with reference to the stars down to the third or fourth magnitude, which he could observe there. He was very careful to discuss, in relation to the Milky Way and certain galactic zones, the distribution of the various kinds of stars which he was fortunate enough to photograph.

We notice that if we deal with the gaseous stars the numbers in the north and south polar region are small, and that the numbers nearer the Milky Way are greater, so that finally we can see exactly how these bodies are distributed. If we take the gaseous, that is to say the hottest, stars, we find the smallest number in the polar regions; but if we take the metallic stars we find practically the largest number, at all events a considerable number, in the polar regions. The general result, therefore, is that the gaseous stars are mostly confined to the galactic zones, the proto-metallic stars are not so confined, that is to say, down to about 3½ magnitude. What is also shown there is that the metallic-fluting stars are practically equally distributed over the polar regions and over the plane of the Milky Way itself: so that, in that respect, we get for these stars very much the equivalent of the result arrived at by Dunér, that is to say, they have little preference for the Milky Way.

(*To be continued.*)

THE PARENT-ROCK OF THE SOUTH AFRICAN DIAMOND.[1]

DIAMONDS were discovered in gravels of the Orange River in 1867, and were traced three years later to a peculiar earthy material called from its colour "yellow ground" by the miners. This, which was soon found to pass down into a more solid and dark-coloured material called "blue ground," occupies "pipes" in the country rock—carbonaceous shales and grits belonging to the Karoo system; the one standing in much the same relation to the other as do the volcanic necks to the carboniferous strata in Fifeshire. Flows or sills of basaltic rocks are associated with the sedimentary strata, and both are cut by dykes. The matrix of the blue ground is a fine granular mixture, chiefly consisting of a carbonate (calcite or dolomite) and serpentine. In this are embedded grains of garnet (mostly pyrope), pyroxenes (a chrome diopside, smaragdite or enstatite), a brown mica, magnetite and other ores of iron, and some other minerals more sparsely distributed. Rock fragments also occur; some of them are the ordinary shale and grit, but others are compact and of an uncertain aspect. Crystalline rocks are sometimes found.

As to the nature of this blue ground and the origin of the diamond, very diverse opinions have been expressed. The late Prof. Carvill Lewis considered the former to be a porphyritic peridotite, more or less serpentinised, which sometimes passed into a breccia or a tuff, and the diamond to have been formed *in situ* by the action of this very basic igneous rock upon the carbon present in the Karoo beds. Others, however, maintained that the rock was truly clastic; being produced by the explosive destruction of the sedimentary rocks, together with part of their crystalline floor—was, in fact, a kind of volcanic breccia, subsequently altered by the action of percolating water at a high temperature. But they also differed in opinion as to the genesis of the diamond itself; one party holding it to have been formed *in situ*, by the action of water at a high temperature and pressure, the other considering it, like the garnets, pyroxenes, &c., to have been formed in some deep-seated holocrystalline rock mass, and to have been set free, like them, by explosive action.

A few months ago the investigation had advanced thus far: (1) study of the diamonds obtained from the blue ground had increased the probability of their being derivative minerals; (2) no certain proof of the former existence of a compact or glassy peridotite had been discovered; (3) certain compact rock fragments, as to the origin of which the writer had at first hesitated to express an opinion, had been determined by him to be only argillites, affected first by the action of heat, then of water; (4) the diamond and the garnet had been brought into very close relation by the discovery of two specimens, showing the former apparently embedded in the latter. The better of them was accidentally picked up at a depth of about 300 feet in a shaft at the Newlands Mines, West

[1] The substance of a paper read before the Royal Society on June 1.

Griqualand (about forty-two miles to the north-west of the more famous group in the neighbourhood of Kimberley). In this specimen a rather large and irregularly shaped pyrope projects from one end of a fragment of blue ground: one small diamond is embedded in this pyrope, and five others either indent it or are in close contact. Fortunately the discoverer was the managing director of the company, Mr. G. Trubenbach, who appreciated its importance, and so kept a sharp look-out for anything remarkable which might turn up during the excavations. Accordingly he preserved specimens of certain boulders, sometimes over a foot in diameter, well rounded and just like stones from a torrent, which occasionally occurred in the blue ground at various depths down to 300 feet. Several of these contained garnets, being varieties of eclogite, but diabase was also obtained.[1] Some of these Mr. Trubenbach brought to London, and on the outer surface of one a small diamond was detected. The boulder was broken, and others were exposed. A fragment (rather less than a third) was sent to Sir W. Crookes, who entrusted it for examination to the writer, and to him Mr. Trubenbach afterwards sent other boulders, besides rock and mineral specimens, with the permission of the directors.

In addition to the boulder of diabase, which has no special interest beyond the fact of its occurrence, there are six boulders of eclogite (one perfect, the rest having been broken), all but one (which may have been four or five inches long) measuring a foot across, more or less. Three of these consist almost entirely of a garnet (pyrope) and an augite (chrome diopside), the former varying in size from a large pea downwards, and the other mineral corresponding. The pyrope is often surrounded, especially towards the exterior of the boulder, by a "kelyphite rim" consisting mainly of a brown mica. This and a few other minerals were present elsewhere, but in very small quantities. The remaining three boulders consisted of the same two constituents, with the addition of a considerable amount of a variety of bastite and a few flakes of brown mica. Of the first group of specimens two contain diamonds, the first-named having at least nine and another certainly one, perhaps a second. All are small, the largest being about ·15 inch in diameter. They are well-formed octahedra, with slightly stepped faces, perfectly colourless, with an excellent lustre. Evidently they are just as much an accidental constituent of the eclogite as a zircon might be of a granite or syenite.

This discovery leads to the following conclusions. As the diamond is found in boulders of eclogite, and these are truly water-worn, that rock is the birth-place, or at any rate one birth-place, of the diamond (for its occurrence in a more basic species, such as a peridotite, may be expected). Hence the diamond is not produced in the blue ground, but is present in it as a derivative from older rocks, in the same way as the olivine, the garnets, the various pyroxenes, &c. Moreover, the blue ground is a true clastic rock, and not a serpentinised peridotite of any kind, so that the name Kimberlite, proposed for it by Prof. Lewis, must disappear from that group. The rock is a volcanic breccia, though a rather peculiar one, for scoria has not yet been detected in it. Probably it was formed by explosions due to pent-up steam, the vents being driven through the upper part of the crystalline floor and the overlying sedimentaries. These never ejected lava, and were soon choked up with shattered material. Through this, in all probability, steam or heated water continued to be discharged for a considerable time, which accounts for the marked changes effected in the exterior of the larger fragments and in the more finely pulverised material of the matrix.

T. G. BONNEY.

[1] The occurrence of boulders in the blue ground at De Beers Mine was asserted by Stelzner in 1893 (*Sitzungber. u. Abhandl. der Isis*, 1893, p. 71).

NOTES.

WE are informed that copies in bronze of the medal presented to Sir G. G. Stokes at his jubilee can now be obtained from Messrs. Macmillan and Bowes, Cambridge, price 15*s*. each.

AT the opening meeting of the new session of the Institution of Civil Engineers, on November 7, an address will be given by the president, Sir Douglas Fox, and the prizes and medals awarded by the Council will be presented.

A GOLD medal is offered by the Cercle industriel agricole et commercial, Milan, for the description of a method, or the construction of apparatus, which will assist in the prevention of accidents to artizans engaged in electrical work.

A CONVERSAZIONE of the Geologists' Association will be held in the library of University College on Friday, November 3. A number of pictures and objects of geological interest will be on view during the evening.

THE Allahabad *Pioneer Mail* (October 6) states that Mr. Douglas Freshfield has started from Darjeeling, with a party of friends and Alpine guides, to explore the glaciers and little-known passes of the Kanchenjunga range. The exact course to be pursued is probably unknown to the party themselves, who must be guided by circumstances; but any addition to the scanty and inaccurate information at present extant on the subject of the Himalayan giant will be welcome to geographers.

IT is stated that another British exploring expedition to Abyssinia has been arranged, and will leave England at once. The members are Mr. James J. Harrison, Mr. Powell Cotton, Mr. W. Fitzhugh Whitehouse (of Newport, Rhode Island) and Mr. A. E. Butter. Mr. Donald Clarke will go as surveyor and geographer, and a taxidermist will also accompany the party. The objects of the expedition are scientific and sporting, and it is expected that the journey will occupy about nine months.

THE thirty-eighth annual general meeting of the Yorkshire Naturalists' Union is to be held at Harrogate to-day, and an address upon the evolution of plants will be given by Mr. William West, the retiring president. The Union is a model of a well-organised local society, which not only serves to develop interest in science, but also assists in the extension of natural knowledge. The membership is not in any way commensurate with the importance of the work carried on, and we are glad to see that efforts are to be made during the forthcoming winter to bring the claims of the Union for support before the naturalists and the public of the County of York.

THE *British Central Africa Gazette*, published at Zomba, always contains several items of scientific interest, and the latest number received, dated August 24, is not deficient in this respect. We learn from this source that Mr. J. E. S. Moore has been taking soundings at the north end of Lake Nyasa. Off Ruarwe a depth of 418 fathoms was found, and off the higher parts of Livingstone Range bottom was reached at 210 fathoms. —Mr. Poulett Weatherley describes in a letter a difficult journey up the Luapula, and through its innumerable rapids. The Luela is regarded as the second most important tributary of the Luapula, but there is little to choose between the Luombwa, the Luela, the Mwyangashe and the Luongo, though the Luombwa is the largest and most delightful of the four.

REUTER's correspondent with Major Gibbons' trans-African expedition reports from Lialui (Barotsiland), in a despatch dated August 5, that much valuable exploring work had been done by the members of the expedition. The routes traversed by the travellers since last January amount in the aggregate to 3500 miles, mostly through unknown or unexplored districts.

The plans of the party at the date of the despatch are reported to have been as follows:—At the end of this month Captains Quicke and Hamilton will travel east to the Kafukwe, while Major Gibbons will make a journey up the Zambesi with canoes to Nanakandundu, returning by river as far as the Kabompo confluence, whence he will make a line to the Kafukwe. Captain Hamilton will then travel down that river to its confluence with the Zambesi, where an aluminium boat awaits him, in which he will descend the river to Zumbo, and return home *via* the east coast. Major Gibbons with Captain Quicke will travel up the Kafukwe, and, after following the Zambesi from its source to Nanakandundu, will make for St. Paul de Loanda on the west coast. All three hope to reach the coast in December by their respective routes.

THE long-standing question as to the admittance of women into full fellowship of scientific societies was brought before a meeting of the Lady Warwick Agricultural Association for Women on Thursday last, and the following resolution, supported by a paper by Mrs. Farquharson, was adopted: "That it is desirable and important that duly qualified women should have the advantages of full fellowship in scientific and other learned societies, *e.g.* the Royal, the Linnean and the Royal Microscopical." The arguments in favour of and in opposition to this proposal have been stated so many times that most members of scientific societies are familiar with them. Six years ago the Council of the Royal Geographical Society elected several ladies as fellows, but their action was disapproved at two special meetings, and resolutions to the effect that it was inexpedient to admit ladies as ordinary fellows were carried by conclusive votes. Ladies are, however, admitted to the meetings of the Society, and papers are accepted from them. In the case of the Royal Astronomical Society, ladies are only admitted to the ordinary evening meetings by special invitation of the president, sanctioned by the Council, the invitations being issued at the commencement of each session. The time may of course come when women will be equally eligible with men for membership of the learned societies, but facts such as those cited show that there is distinct opposition to the admittance of women at present, and no sudden change of feeling can be expected, though individual cases of "duly qualified" women might be considered.

IN a review which appeared in NATURE of September 7 (p. 433), reference was made to the hair of a "Panyan woman," figured as a "Negrito type, India," in Prof. A. H. Keane's work on "Man, Past and Present." Mr. Thurston's original photograph, from which the illustration was reproduced, shows the hair of the woman as of a distinctly curly character, "which feature," the writer of the review remarked, "is unfortunately lost in Keane's reproduction." Prof. Keane writes to say that his picture is a facsimile of Mr. Thurston's photograph, and shows the curly hair portrayed in the original. In support of his case he has submitted the portrait and the reproduction to us, and we must confess our inability to distinguish any obvious difference between them. The writer of the notice maintains, however, that the hair is not quite the same in the two, and he unites with Prof. Keane in the hope that every one interested in the matter will compare the illustrations for themselves before accepting either view.

DR. C. LE NEVE FOSTER reports, in a Blue Book just issued ("Mines and Quarries: General Report and Statistics for 1898," part iii.), that the total value of all minerals raised in the United Kingdom in 1898 exceeded 77,000,000*l.*, being an increase of five millions compared with the previous year. The output of coal during the year exceeded 202 million tons, of which 36½ million tons were exported. This large export of coal induces Dr. Foster to call attention to the plain warning contained in Mr. T. Forster Brown's paper on "Our Coal Supplies" (*Journal* Society of Arts, 1899, p. 508), in which it is emphatically stated that in another fifty years the dearth of cheap coal will begin to be felt. Referring to this, Dr. Foster says: "We are already dependent upon foreign countries for much of our iron ore, and it will be an evil day when we feel the pinch of poverty in coal. The proper husbanding of the coal resources of the kingdom is therefore a question of national importance."

THE great success of the installations for the development of electricity by power obtained from Niagara Falls is naturally leading enterprising capitalists in many other parts of the world to consider similar projects. We learn, for instance, from the *Pioneer Mail* that within the last few months schemes have been ventilated for utilising the Nerbudda at the Marble Rocks for supplying power to the new gun-carriage factory to be erected near Jubbulpore. There is also a project for running the Kashmir railway by electricity, the power being taken from the Chenab. Then there is another plan for supplying electrical power to Murree, deriving the energy from the Jhelum, which runs within ten or twelve miles of that sanatorium. For Simla there are no less than two schemes for obtaining electrical power by hydraulic means: one from the Sutlej, and another from a proposed lake to be made in the nullah below the station. Assuming that the majority of these schemes are practical, the point which remains somewhat obscure for the present is whether the demand for electricity in any of the places named would be sufficiently great to make the undertaking a commercial success.

THE *Experiment Station Record* (No. 5) of the U.S. Department of Agriculture contains a description of the biological and dairy building recently completed by the New York State experiment station at Geneva. The building has been constructed and equipped by the State for the study of dairy problems, and especially those concerned with cheese-making. The changes which take place during the curing of cheese, and the conditions which influence them, are still so imperfectly understood that the work carried on in the new laboratories is sure to lead to valuable results. Arrangements are provided for studying the ripening process in all its phases; and a bacteriologist is attached to the staff.

A NUMBER of excellent photographs obtained with a telephoto lens, by Mr. D. L. Elmendorf, are reproduced in the current number of *Scribner's Magazine*. A telephoto attachment, consisting of a negative lens, with a rack and pinion mounting, was used upon an ordinary rectilinear lens to take the pictures. With this attachment eight inches from the plate, the image obtained was equal to that formed by an ordinary lens of twenty-four inches focus; while at twenty-four inches from the plate, this being the greatest extension of the camera employed, the combination was equivalent to a lens of sixty-four inches focus. Among the striking pictures which accompany Mr. Elmendorf's article are views of the Jungfrau, obtained at a distance of sixteen miles, and of the cone of Popocatepetl, Mexico, taken at a distance of thirty miles.

THE Pilot Chart of the North Atlantic Ocean for the current month contains some further interesting particulars respecting the track of the destructive West India hurricane of August 3–September 12. After leaving the American coast it at first moved eastward with increased velocity. During the week of August 24–30 it remained almost stationary in the mid-Atlantic, the centre of the disturbance shifting to the northward, from where it took an almost due easterly course to about longitude 20°, traversing the Azores on September 3; it then curved to the N.E. until it reached the vicinity of Brest on September 7, when it bent in a S.E. direction and reached the north of

Corsica on September 9. Whole gales were frequently encountered throughout the course of the storm across the Atlantic. Off the coast of Provence it caused strong N.W. gales and a rough sea on September 9–11. This hurricane can be traced over the North Atlantic for a period of thirty-six days, making it in length of life the most noteworthy storm ever reported to the Hydrographic Office in Washington.

A SUMMARY of divers and sundry views respecting the cause of formation of hail is given by Signor Pio Bettoni in the *Bolletino mensuale* of the Italian Meteorological Society. The great divergence of opinion on the subject seems to suggest that we have not made much advance towards arriving at a definite explanation of the phenomenon during the century which has elapsed since Volta published his well-known electrostatic theory. Of the views here enumerated some are modifications of Volta's theory, and attribute the formation of hail to electrostatic causes, others ascribe the phenomenon to whirlwinds (vortices), others, again, to refrigerating air currents, and even the more unconventional theories, according to which hailstones come to the earth from interplanetary space or their refrigeration is due to transmutation of caloric into electricity, are not without their advocates.

IN *Himmel und Erde* for September, Dr. E. Less, of the Berlin Meteorological Office, gives a very lucid account of the general circulation of the atmosphere. In the first half of this century our knowledge of weather changes was almost exclusively confined to climatological investigations, in which Prof. Dove, of Berlin, was the most prominent representative; he referred the origin of all winds to an interchange of the air between the equator and the poles. But the study of synoptic weather charts, from about the year 1860, showed that the explanation hitherto given of weather changes did not generally accord with observed facts, and that they were intimately connected with the existence of areas of high or low barometrical conditions. The author points out that while the behaviour of the great atmospherical currents is, generally speaking, capable of explanation, the relation between them and the smaller disturbances which occur in our latitudes leave many doubtful points to be cleared up. In fact, what part is played by the general and what by the local conditions in producing the different phases of weather is as yet but little understood. The explanation of these phenomena is one of the most important problems of meteorological research, the solution of which must be approached in various ways.

THE *Bulletin International* of the Cracow Academy contains a notice of a paper, by M. P. Rudski, on the theory of the physics of the earth. In it the author gives a mathematical investigation of the variation of latitude in an elastic spheroid covered with water, and investigates the earth's rigidity as deduced from the 430-day period of the variation. The values deduced depend on the assumed "effective density" of the earth. Taking for this density the values 2·2, 3·0, 4·0, 4·5 and 5·5, Rudski finds the corresponding values of the rigidity to be 567, 879, 1713, 2036 and 2681 times 10^9 C.G.S. units respectively, that of steel being 819×10^9. By neglecting the effects of the ocean, and taking for the effective density the value 5·5, the author finds $n = 1250 \times 10^9$.

WITH a view of contributing data towards the determination of the secular variations of the earth's magnetism, Dr. Emilio Oddone contributes to the *Rendiconti del R. Istituto Lombardo*, xxxii. 15, his determinations of the magnetic elements at Pavia for June 1898, which admit of comparison with the corresponding elements determined by him at the same spot about fifteen years ago. The present results are as follows: declination, 11° 48′ ± 2′; inclination, 61° 26′ ± 2′; intensity in C.G.S. units, horizontal, $0{\cdot}216_3 \pm 0{\cdot}001$; vertical, $0{\cdot}397_3$; total, $0{\cdot}452_4$. While the interval between the present and the previous determination is too short to allow of these observations being made the basis of a new determination of the secular variations of the earth's magnetism, the author remarks that the empiric formulæ for the inclination and horizontal intensity, when exterpolated for fifteen years, agree fairly well with the above-mentioned numbers, but the annual variation in late years comes out to be less than was to be inferred from past observations.

PROFS. ELSTER AND GEITEL, writing in *Wiedemann's Annalen*, 69, discuss the source of energy in Becquerel rays, and advance the theory that the rays may be due to changes of the molecular arrangement of the atoms of the radio-active substance in which these pass from an unstable to a stable configuration with expenditure of energy. In a second note, the same authors show that Becquerel rays experience no deviation from a magnetic field, but that such a field in certain circumstances decreases the electro-dispersive power of air that has been traversed by them.

IN a communication to *Wiedemann's Annalen*, 67, Herr K. Kahle describes at some length experiments with the silver voltameter and their applications to determine the electromotive force of normal elements. The object of the paper is to obtain the electromotive force of the Clark cell, previously determined by the author by means of Helmholtz's electro-dynamometer, independently from the electro-chemical equivalent of silver. The value now obtained for the ratio of the Clark at 15° to the cadmium at 20° is 1·40663. Herr Kahle infers the following results as correct to 2 in 10,000, viz. Clark, 15°: $1{\cdot}4328_5$; cadmium, 20°: $1{\cdot}0186_3$; and Clark, 0°: 1·4492 internal volts.

DR. FRANZ KERNTLER has published a paper on the unity of the absolute system of units in relation to electric and magnetic measurements, in which he proposes to supersede the present dual systems of electrostatic and electromagnetic units. According to Dr. Kerntler's system, quantity of electricity and quantity of magnetism are both measured by Coulomb's law in C.G.S. units, and are thus both of the same dimensions, being identical with the electrostatic and magnetic units respectively; but a current has two measures, which Dr. Kerntler designates as its "opulence" and its "fecundity." These, which represent its electromagnetic and electrostatic measurements in common parlance, are in the ratio of 1 to "v."

DR. F. J. ALLEN has contributed to the *Proceedings* of the Birmingham Natural History and Philosophical Society, xi. 1, an essay on the nature and origin of life. The author remarks that the most prominent and perhaps most fundamental phenomenon of life is what may be described as the energy traffic or the function of trading in energy. After briefly pointing out the differences between anabolism and catabolism, Dr. Allen advances the opinion that it is nitrogen which, in virtue of its variability, instability, and lability, plays the most important part in the phenomena of life, and he enunciates the law that every vital action involves the passage of oxygen either to or from nitrogen. In the section dealing with the origin of life, it is stated that life in its physical aspect is the culmination of that chemical instability in certain elements which has always kept them circulating at the earth's surface. Dr. Allen considers that existing conditions are favourable to the origination of primitive forms of vital processes at the present time, and the reason that such forms do not originate now is that the elements required for their development are seized and assimilated by the already developed organisms. In regard to the possible existence of life in other parts of the universe, the same conditions of instability which are peculiar to the group of elements nitrogen, oxygen, carbon, and hydrogen at ordinary temperatures on our earth's surface may exist in other groups of elements at widely different temperatures, giving rise in parts of the universe, even of the most diverse characters, to developments of life whose variety and magnificence are beyond the utmost reach of our imagination.

A PAPER, entitled "Wanted, Plant Doctors," is to be found in the current issue of the *Contemporary Review*, in which the importance of the subject of plant pathology is briefly dealt with. While giving credit to the workers at the British Museum, Kew, &c., for the attention they are paying to this branch of science, the writer of the paper shows how far behind America and Germany this country is in recognising the importance of the subject. He thinks, however, that this will not be always so; "a time must come when every agricultural district will have its plant doctor, and when specialists in animal parasites, cryptogamic botany, and bacteriology will be consulted in difficult and obscure cases, just as the help of Harley Street is called in by medical practitioners. The practice of plant medicine is in its infancy; but with increased competition in the growth of cultivated crops, the farmer cannot afford to neglect any help that he can get in keeping the plants under his care in as high a state of health as possible." "What better use," adds the writer, "can be found for a philanthropist's money than the founding of a school of practical plant pathology, for the investigation of the diseases which occur in Britain?"

IN the October number of the *Zoologist* the editor, Mr. W. L. Distant, continues his communication on mimicry. While referring only to a limited number of examples, he divides his subject primarily into demonstrated, suggested and disputed cases of mimicry; adding a section on purposeless mimicry, and a second devoted to active mimicry. Under the heading of suggested mimicry the curious resemblances between certain tree-shrews and squirrels, as well as that between the Cape hunting-dog and the spotted hyæna, are rightly included; but it seems a little curious to find the East African Guereza monkey, whose coat has been shown by Dr. J. W. Gregory to present such a remarkable resemblance to the pendent lichens of the trees on which the animal lives, included in the same category. Under the heading of purposeless mimicry are included cases like the resemblance of the bee-orchis to the insect from which it takes its name; while active mimicry denotes those instances where insects or other creatures take special measures to avail themselves of their resemblance to other objects.

THE same journal likewise contains a very suggestive paper by Mr. C. Oldham on the mode in which bats secure their insect prey. It has been observed that these animals, when walking, carry the tail curved downwards and forwards, so that the membrane connecting this organ with the hind legs forms a kind of pouch or bag. If a large insect be encountered the bat seizes it with a snatch, and slightly spreading its folded wings and pressing them on the ground in order to steady itself, brings its feet forwards so as to increase the capacity of the tail-pouch, into which, by bending its neck and thrusting its head beneath the body, it pushes the insect. Although the latter, especially if large, will often struggle violently, when once in the pouch from which it is subsequently extracted and devoured t but rarely escapes. It is assumed that the s ıme method of capture is employed when on the wing; and a correspondent of the author, who has observed the long-eared bat picking moths off sallows, states that "the bat always hovers when taking off the moth, and bends up the tail so as to form a receptacle for the insect as it drops."

MR. G. C. WHIPPLE and Mr. D. D. Jackson reprint, from the *Journal* of the New England Water-works Association, a paper on *Asterionella formosa*, a diatom which sometimes appears in great quantities in reservoirs of drinking water, imparting to it a geranium-like or fishy odour, from the production of a substance analogous to the essential oils. Its development is seasonal, appearing chiefly in spring and autumn. Its growth is greatly favoured by strong light; and the most efficacious preventative appears to be the storage of the water in the dark.

THE Director of the Botanical Garden at Buitenzorg, Java, has issued the first number of a *Bulletin* of the Botanical Institute, containing a history of the Institute down to the present time, a plan of the buildings and of the gardens, with a list of the plants grown in them, and a list of the official publications. Besides the special laboratory for workers from other countries, the Institute contains laboratories for agricultural chemistry, for phyto-pathology, for agricultural zoology, for pharmacology, and for the study of the coffee and tobacco plants.

PROF. DAVID G. FAIRCHILD gives, in the *Botanical Gazette* for September, an interesting account of a visit to Payta, in Peru, reputed to be the driest spot on the face of the globe. Payta is situated about 5° S. of the equator on a coast which has risen 40 feet within historic times. The average interval between two showers is seven years; when Mr. Barbour Lathrop and Prof. Fairchild visited it in February, there had recently been rain lasting from 10 p.m. one day till noon the next day, the first for eight years. There are frequent sea-fogs. The flora consists of about nine species; of these seven are annuals, the seeds of which must have remained dormant in the ground for eight years. Notwithstanding the scarcity of rain, the natives subsist by the growth of the long-rooted Peruvian cotton, which is able to maintain itself without rain for seven years in the dried-up river-bed, and yields profitable crops of the coloured short staple cotton, which is used as an adulterant for wool.

THE Calendar, for the session 1899-1900, of the University College of North Wales has just been issued by J. E. Cornish, Manchester; and the University Correspondence College Press has published its London University Guide for the same period.

THE *Bulletin of Miscellaneous Information* (Botanical Department) for Trinidad, No. 20, July 1899) contains a report, by Mr. G. Massee, on the cacao-pod disease, in which he states that, in addition to the well-known *Phytophthora omnivora*, a second parasitic fungus, *Nectria Bainii*, sp. n., occurs on the diseased pods.

WE have received from the Purdue University Agricultural Experiment Station at Lafayette, Indiana, a parcel of reports (*Bulletins* Nos. 71-79) on various subjects o' practical importance to agriculturists:—The San José and other scale insects; field experiments with wheat; skim milk as food for young growing chicken, &c.

PROF. ELMER GATES describes in the *Scientific American* a number of pictures he has obtained of the electric discharge, by placing a photographic plate between the two poles of a ten-plate electrostatic machine. The illustrations accompanying the article are of much the same character as those given by Lord Armstrong in his elaborate work on "Electric Movement in Air and Water," but they are on a smaller scale, and therefore less full of detail.

A NEW edition—the fourth—of "Our Secret Friends and Foes," by Prof. Percy Frankland, F.R.S., has been published by the S.P.C.K. The author has re-written the chapter which was added to the immediately preceding edition, and has added some of the latest results achieved in the study of bacterial poisons, such as that of bubonic plague, and of some other poisons of a non-bacterial origin.

MESSRS. LONGMANS AND CO. have issued a new edition of Prof. Lloyd Morgan's "Animal Biology." The book was originally published twelve years ago to meet the requirements of the Intermediate Science and Preliminary Scientific Examinations of the London University. The present edition has been revised, and some chapters re-written, to meet the requirements of the existing syllabus. Several illustrations now appear in the work for the first time.

NEW editions of two well-known books of chemistry (Ostwald's "Grundriss der Allgemeinen Chemie," and Lothar Meyer's "Outlines of Theoretical Chemistry," the latter translated by Profs. Bedson and Williams) have recently come to us from their publishers—Engelmann of Leipzig, and Longmans and Co The former is a third edition, and the latter a second, and an attempt has been made in each case to bring the work up to date.

REFERENCES to practically every article and work on geography published during the year 1896 will be found in the fifth volume of the "Bibliotheca Geographica," prepared by Dr. Otto Baschin for the Berlin Geographical Society, and just published by the firm of W. H. Kühl. A comprehensive classification of subjects is adopted, and it is easy to find the works published in any branch of geography in 1896. In addtion, there is a complete index of authors. Students of geography know the work so well that no comment upon its thoroughness is necessary here.

THE additions to the Zoological Society's Gardens during the past week include a Green Monkey (*Cercopithecus callitrichus*) from West Africa, presented by Mr. G. P. Kinahan; a Macaque Monkey (*Macacus cynomolgus*) from India, presented by Mr. A. M. Burgess; a Gambian Pouched Rat (*Cricetomys gambianus*), a Nilotic Trionyx (*Trionyx truinguis*) from Sierra Leone, presented by Mr. Ernest E. Austen; a Red-footed Ground Squirrel (*Xerus erythropus*) from West Africa, presented by Mr. F. H. D. Negus; two Herring Gulls (*Larus argentatus*), British, presented by Mr. J. W. Edgar; a Melodious Jay Thrush (*Leucodioptron canorum*) from China, presented by Mrs. Currey; a Spoonbill (*Platalea leucorodia*), a Kestrel (*Tinnunculus alaudarius*), captured at sea, presented by Captain E. W. Burnett; a Green Turtle (*Chelone viridis*) from Ascension, presented by Mr. W. Hebden, C.E.; a Chameleon (*Chamaeleon vulgaris*) from North Africa, presented by Mr. F. G. Ward; two Serrated Terrapins (*Chrysemys scripta*) from North America, a Bennett's Cassowary (*Casuarius bennetti*) from New Britain, a White Goshawk (*Astur novae-hollandiae*), two Sacred Kingfishers (*Halcyon sancta*) from Australia, a Forsten's Lorikeet (*Trichoglossus forsteni*) from the Island of Sambawa, a Ring Ouzel (*Turdus torquatus*), British, deposited; a Crab-eating Raccoon (*Procyon cancrivorus*), two Short-eared Owls (*Asio brachyotus*) from South America, purchased.

OUR ASTRONOMICAL COLUMN.

HOLMES' COMET (1899 *d*).

Ephemeris for 12*h. Greenwich Mean Time.*

1899.		R.A. h. m. s.		Decl. ° ′ ″
Oct. 26	...	2 45 7·14	...	+49 11 29·7
27	...	43 55·55	...	13 2·6
28	...	42 43·32	...	14 12·0
29	...	41 30·56	...	14 58·0
30	...	40 17·40	...	15 20·5
31	...	39 3·95	...	15 19·6
Nov. 1	...	37 50·33	...	14 55·4
2	...	2 36 36·67	...	+49 14 8·0

NOVA SAGITTARII.—*Harvard College Observatory Circular*, No. 46, gives the details of the position of Nova Sagittarii, discovered in April 1898, as obtained from micrometric measurement of enlargements from the plates, taken with the 8-inch Bache and 11-inch Draper telescopes, on which the star was photographed. Prof. Pickering finds that the accuracy obtainable by this method is equal to that given by the best meridian circle observations. The mean position as determined is

$$\left.\begin{array}{l}\text{R.A.} = \text{18h. 56m. 12·83s.}\\ \text{Decl.} = -\ 13^\circ\ 18'\ 12''\!\cdot\!98\end{array}\right\}(1900).$$

ORBIT OF EROS.—In the *Astronomische Nachrichten* (Bd. 150, No. 3597), Herr Hans Osten, of Bremen, discusses the numerous observations of the new minor planet now available, and gives the two following provisional sets of elements for the orbit:—

Epoch of Nodal Passage, 1898 *Oct.* 1·0. *Berlin Mean Time.*

	I. ° ′ ″		II. ° ′ ″
$M =$	238 38 33·627	...	238 39 44·636
$\omega =$	137 9 24·77	...	177 39 21·05
☊ =	342 8 48·58	...	303 31 53·37
$i =$	30 42 32·105	...	10 49 33·99
$\phi =$	12 52 17·14	...	12 52 18·33
$\mu =$	2015″·57814	...	2015″·34326
$\log a =$	0·1637380		

STRASSBURG OBSERVATORY.—The annual publication compiled under the supervision of Herr E. Becker, the director of the Imperial Observatory of the University of Strassburg, has recently been issued, containing the reductions of star observations made during the period 1882–1888, together with miscellaneous results to 1893. The observations made with the meridian circle, occupying 154 pages, are preceded by some twenty pages giving details of the determination of collimation, level, azimuth and other corrections. Following these are given the individual observations of the positions of 223 stars measured from 1882–1883, and of 1146 stars measured during the period 1884–1888. From these three catalogues are compiled, one of 254, one of 858, and one of 368 stars, the latter containing corrections from Epoch 1880. Three appendices deal with heliometer measures of the partial solar eclipses of 1890, 1891 and 1893, the determination of the form the pivots of the meridian circle of the observatory, and the compilation of precession tables (both annual and secular) respectively.

THE NERVE-WAVE (LA VIBRATION NERVEUSE).[1]

AS you told us, sir, two days ago in your admirable address, the century now drawing to an end is most honoured in the close union of men of science of all nations. If, owing to stupid prejudices and barbaric hate, nations are still separated by divisions which may lead them into fratricidal war, it falls to the men of science at least to set the example of concord, in order that by their teaching, based on reason, they may bring to all peace, sweet peace—the chimæra of the past, the hope of us all to-day, the reality of to-morrow. To this end nothing can be more effective than the great example of the British Association and the Association Française, who, within the space of a few days, are to meet twice as partners in their fertile work: to-morrow on English soil, in this hospitable town of Dover; five days later on the soil of France, on the shores you can see from here, where you will find the same courteous and cordial welcome as our countrymen will receive on this side.

Yet after these words of peace must come words of war—nay, its open declaration. Men of science have not the right to stay within the closed gates of their tower of ivory; it behoves them also, even at the cost of vain popularity, to wrestle and to wrestle unceasingly for justice; to form a grand international league, to turn the united forces of all generous minds against the common foe, the worst enemy of man: and this is ignorance. We must not value unduly the admirable conquests won by science in this century. Admirable as they are, they are yet nothing as compared to the great mystery beyond. Newton compared our science to that of a child, who should pick up a pebble on the

[1] Evening Address delivered by Prof. Charles Richet on September 15, at the Dover Meeting of the British Association. Translated by Prof. Marcus Hartog.

sea shore, and think he has penetrated the secrets of ocean. After all our searchings and all our efforts, to-day we can hardly say more. The shades that surround us are as deep as in the time of Newton; and in this universe, vast and obscure, at most scattered glimmers of light, few and far between, reach our straining eyes.

We need all the co-operation of all men of science, of all nations, to dispel some of these shades. What madness it would be not to unite, not to walk hand in hand, but to strive apart! The reward of this union will be above all price: the conquest of truth, the control of brute matter, the gift of a life less precarious and less painful to man, feeble man.

And so you see what we should think of those self-styled patriots and nationalists, who speak of French science, English science, German science, as if science were not international, and lifted high above our vain frontier limits.

To the history of nerve-waves many workers of diverse countries have contributed their share; as with every great scientific problem, every country of the world has taken part in its solution. But before I go on, let me pray your indulgence for treating of so arid and so difficult a subject before you.

I.

The world around us presents itself in different aspects to the eyes of the student and of the layman. The layman sees external objects, endowed with properties apparently inherent in them, and commonly defined by the impressions made on our senses. A given object is warm, light, electrified, heavy, and so forth; and every one thinks that heat, light, electricity, weight, are so many realities, distinct from the object itself. But the man of science conceives matters otherwise. For him this vast universe is formed of an indefinite "something" termed "Energy," and he knows that this force may have different manifestations in motions of diverse kinds. We are almost justified in saying that "Energy is one"; that its aspects appear to our senses so different because the various movements of this energy have not all the same qualities. They differ in number, in frequency, in rapidity, in form; and according to these different modalities which we perceive, and to their results, we have heat, light, electricity, attraction.

The movements of this energy are all transmitted in the same way, by wave-motion—"undulation" or "vibration," as we call it; and the physicists, by wonderful research, in which the highest mathematics must be utilised, have succeeded in determining the forms of certain kinds of these waves. And even those motions of energy which we do not so well understand, we are justified, by what we do know, in regarding also as wave-motions or undulations.

I need not dwell on this phenomenon of undulation or vibration. We all know the simple case when a pebble is dropped into still water; and the surface, which was smooth as a mirror, now shows a series of disturbances propagated in ever-widening concentric circles. In each oscillation we see two periods: in the one the water recedes from the primitive plane of the mirror, in the other it comes back to it again. The former is the *period of departure*, the latter that of *return*.

So, if we hit a hanging weight, a pendulum, the shock at once removes it from its position of equilibrium, and it recedes further from it (period of departure); then it comes back again to its starting point (period of return). What I have called undulation and vibration are two names for the same phenomenon, of the greatest diversity in form, but essentually due to the wave-motion of a fluid. Though, if you will, this fluid, the ether, be of very hypothetical character, we will take it for granted here, and say that heat, light, electricity, gravitation, are all wave-motions of the ether.

Consequently, the outer world in its infinite diversity of aspect, in form and in colour, is the sum total of the various vibrations of force. These vibrations, most diverse in character and in intensity, act upon the living organism, and produce sensations therein. Now it is probable that, as I shall try to show you directly, these vibrations of the outer world only act on our senses by evoking within us another kind of vibration, to which are due sensation and perception. Thus the nerve-wave is revealed to us as the goal and the final term of the vibrations of the external world. Were there no nerve-wave, though, no doubt, all these external vibrations would still exist, still they could produce no effect on us. In virtue of its own proper vibrations, the living being becomes the microcosm, the recipient of the diverse vibrations of the macrocosm, the universe: by these vibrations only is the universe accessible to our understanding. Thus you see what of interest lies in the study of this nervous vibration, since through it the outer world is known to us, and through it we have the power to act on the outer world.

II.

This study is no new one; I should trespass beyond the limits of your courteous attention were I to try and recount all the classical facts that are well known at present. Yet, that you may understand the new facts I am coming to presently, I shall have to give you a short summary of some of these classical facts; and I hope that despite their being so well known, they will not be devoid of interest to you.

The nervous system is made up of distinct elements, each consisting of a cell, with very long fibrous outgrowths. These cells with part of their outgrowths are compacted into the central nervous system, while the rest of the outgrowths are produced into strands, the peripheral nerves. An elaborate microscopical analysis of the last few years, largely due to Golgi and to Ramon y Cajal, have shown that the total number of processes is countless. Each cell sends forth at least one outgrowth, the *axis cylinder*, which remains unbranched except at its very termination; while the others, like the branching roots of a forest tree, spread out in all directions, so that they interlace with those of its neighbours. Thus all the nerve-cells are in communication; the disturbance of one may affect all. And this disturbance may be propagated far and wide; for in the peripheral nerves pass out the axis-cylinders, which separate ultimately and get up to the very tips of the limbs, to the skin, the entrails, the muscles, and the glands. Think of the whole surface of the skin as provided with little nerve apparatuses, all capable of vibration and of transmitting their undulations through the sensory nerve-fibres to the nerve-centres; of the nerve-centres as possessing processes like the sensory fibres, whereby to transmit their orders to the muscular and glandular organs; and you will be able to realise the part played by the nerves in the life of the organism. It is a vast telegraphic apparatus, to receive, by its sensory receptive mechanism, all impressions from without, and to transmit, by its transmitting mechanism, corresponding messages to the organs of motion, the muscles. And, since all the nerve-cells are, moreover, in communication with one another, and since every living cell is in relation with nerves, we may sum up the relations of the living organism in this general formula: through the nervous system, any one living cell reverberates in every other cell, and is reverberated to by every other cell. Thus the living organism that possesses a nervous system is no mere aggregate of cells; it is an *individual*, all the parts of which co-operate for the common weal.

The nerve-cell, together with its prolongations, has received the name of "neuron"; we can conceive that by the inter-relations of all its neurons the living organism may be regarded as one gigantic neuron, sensible to all stimulations at the periphery, and answering them by stimulations of the motor apparatus, which are translated into acts of motion or of secretion. This sensibility and its motor response are linked by a phenomenon which we shall call for the present the "nerve-vibration" or "nerve-wave." How far is this name justified? This is the question that we have to deal with.

III.

Let us for the moment make the assumption (which is not quite exact) that the phenomena are identical in the peripheral nerves and in the central nervous centre, and that what applies to the one will also apply to the other.

We may, at least, accept them as analogous, since the axis-cylinder of the peripheral nerve is an expansion of the protoplasm of the nerve-cell. True, the reactions of the peripheral and of the central nerve tissue are not identical; but their differences are probably in accessories, not in essentials. We may, therefore, boldly accept their analogy, if not their identity; and we are justified in applying to the one the truth that we learn of the other.

The pace at which an impulse travels along a nerve is well known since 1850. Strange to say, just two years before, a great physiologist, one to whom the science is indebted for some of its grandest advances, Johannes Müller, declared that it was impossible for us to determine the speed of nervous transmission—an affirmation as imprudent as are all affirmations which proscribe formal conclusions to the science of the future.

Well, as I say, just two years after this unfortunate prophecy of Johannes Müller, Helmholtz ascertained that, if you determine the time of response by stimulating a nerve at a given point, you can determine the rate of transmission by stimulating the same nerve at a measured distance, say a decimetre, above that point; for, as in this case, the response will be delayed, the period of delay measures the rate the nerve impulse has taken to travel over ten centimetres. Since then countless determinations have been made of the speed of the nerve-current. It has been found to vary with the temperature and with the character of the nerve stimulated; it is less rapid in the nerve-centres than in the peripheral nerves, less in cold-blooded than in homœothermic (or so-called warm-blooded) animals. But it never differs much from thirty metres per second.

Moreover, this nerve current has been found to be always transmitted in both directions from the point of stimulation. I will not dwell on the exceedingly technical proof of this law, but merely recall the fact that whether the nerve stimulated be motor or sensory, the nerve current travels both ways along it, both towards the periphery (skin, muscle, &c., as the case may be) and towards the central nervous system.

A most important fact is that an electrical disturbance accompanies every stimulation of a nerve. If in the undisturbed condition we place the poles of a circuit with an interposed galvanometer at two points of a nerve (one on its surface, the other on a cut end), to ascertain its electric condition, we find that there is an electric tension between them, that there exists in the nerve a certain current. If we then stimulate the nerve, the current is seen to be reversed, or, as we say, undergoes a "negative variation," and the rate at which this change is transmitted is sensibly the same as that of the nerve-wave. Matteucci, Du Bois Reymond, Bernstein, Waller have studied all the complex details of this process; so that it now ranks among the best known phenomena in physiology.

We ask:—Are there, concurrent with this electric variation, modifications in the chemical and thermic condition of the nerve or nerve-centre? Yes, in all probability; but the answer is not certain. Schiff thought that by stimulating the retina of the pigeon he induced a change in the temperature of the brain. Mosso also thought he could find localised areas of higher temperature in the brain after stimulating certain points; but the elevation of temperature is, to say the least, of low intensity and difficult to determine.

In this rapid sketch, the last law I have to formulate is *the law of the integrity of the organ*. The physical and mechanical union may be maintained; but if its organic continuity be severed as by a cut, even when the two ends are joined up, the nerve-current is no longer transmitted.

IV.

Several hypotheses may be put forth as to the nature of this phenomenon.

Formerly, when words were accepted in place of facts, it was said that there was a transference of "animal spirits" (a conception due to Descartes); this was the current expression in the sixteenth, seventeenth and eighteenth centuries. A curious apparent confirmation was found in Richard Lower's experiment: he tied a nerve, and saw that it swelled above the seat of ligature; this, said he, was the accumulation of the animal spirit, arrested by the tightened thread. The experiment was a perfectly valid one; and you see that from it it was possible to deduce conclusions that were perfectly false. The swelling was due to the increase of blood pressure and to inflammation.

We may drop this old hypothesis of "animal spirits," and pass to four theories put forward to explain the nature of the nerve-current.

(1) *Mechanical Hypothesis.*—If, as is probable, the semi-fluid protoplasm of the nerve-cell and its prolongations form one continuous whole, it follows that a mechanical disturbance of this liquid mass will be propagated to a distance along the whole length. Suppose a capillary tube filled with mercury; a disturbance of the mercury will be propagated the length of the tube, so that at the far end we perceive a vibration started from the opposite end. In this case the nerve-wave would be the molecular disturbance of a liquid enclosed in a capillary tube.

This hypothesis would afford a fair explanation of the electrical phenomena involved; for we know that the friction of a fluid in a capillary tube produces electricity. However, this mechanical explanation presents certain difficulties, for in a capillary tube the narrower its calibre the more rapidly the vibration is damped; consequently, it is hard to conceive that a vibration could be transmitted so as to be appreciable at the far end of a tube one or two metres long. It is true that we can form no supposition as to the absolute measurement of such perturbation; and perhaps almost infinitesimally small forces are adequate.

On the other hand, the electric disturbance that accompanies the nerve-wave does not lose intensity as it travels: on the contrary, Pflüger and other physiologists declare that it grows like an avalanche. Hence, taking all considerations into account, the nerve-wave is a phenomenon other than a mechanical vibratory molecular disturbance of the semi-fluid protoplasm.

(2) *Chemical Hypothesis.*—The transmission of the nerve-wave along a nerve has been compared to the explosion of a train of powder, or of mixed gases in a tube; and this you know is transmitted relatively slowly, nay, very slowly if the tube be of capillary dimensions. If, say, an explosive mixture of oxygen and hydrogen be contained in a very narrow tube, and a flame or spark applied at one end, the combustion will not be instantaneous, but will pass as a wave along the tube, and that a very slow wave, if the tube be narrow.

What at first sight would give some plausibility to this hypothesis is the fact that a very feeble stimulus may call forth a very strong response. Take the amount of energy received by a surface of 1 sq. cm. from a candle 300 metres distant; it is 1/10,000 millions of the total light-giving energy of the candle, a quantity whose absolute value is in one sense a negligible quantity, but which is adequate to give a sensory stimulus to the retina. The retina must be supposed to contain a quantity of accumulated energy susceptible of explosive liberation, so that the amount freed would be far in excess of the energy of the stimulus.

But there is one very serious objection to this hypothesis; it demands that the explosive tissue should be reconstituted afresh immediately after each explosion. It is not easy to see how the moment after the explosion, in the hundredth of a second, the nervous substance could be reconstituted afresh. Though serious, the objection is not irrefutable, for we know too little of the speed or slowness of the chemical changes of the organism to use this as an argument against any theory whatever.

(3) *Electrolytic Hypothesis.*—Certain chemical changes are characterised by their allowing of an immediate reconstruction after their occurrence, such are the phenomena of electrolysis. When a current passes through a saline solution, it is believed that, as it passes along, the salt is decomposed from place to place, and immediately reconstituted as soon as the current has passed. The passage of the electrolytic current is sometimes exceedingly slow. There is nothing to prevent our accepting some such explanation of the nerve-wave; it has the advantage that it can be brought more or less into harmony with the chemical and the electrical hypothesis, and can indeed reconcile them.

(4) *Electric Hypothesis.*—This supposes that an electrical current passes along a peculiar form of conductor—the nerve. The chief objection that has been urged, in the extreme slowness of the nerve-wave—30 metres per second—as against 700 million metres, the alleged rate of electricity. But this omits to take account of the fact that electricity travels at this speed in good conductors only. Electricity passes along a conducting wire, ten thousand, a hundred thousand, times as fast as along a badly conducting tube; it is only reasonable to admit that the transport of electricity may be enormously retarded in a capillary tube filled with a very bad conductor. It has also been urged that, since different nerves can transmit very different sensations simultaneously to the different parts of the nervous system, there should be a blurring and confusion from the imperfect insulation of the tubes if it were electricity that they conducted.

"How, for instance," we are asked, "could nerve-cells of the cord and the brain communicate their electrical disturbances in narrowly localised groups with that extraordinary precision, without the neighbouring cells feeling the effect?"

We do not attach much weight to this objection because, in the first place, the axis cylinders have an insulating covering of myeline, as have also the cells of the brain; and again, in electric fishes, electric shocks one hundred thousand-fold as strong pass between certain organs without the rest being at all affected, so perfect is the insulation.

Thus the hypothesis that the nerve-wave is an electric phenomenon is fairly satisfactory, especially if we admit that it resembles electrolytic action.

Certainly we must allow for the unforeseen; we must recognise the possibility that, perchance at no very distant date, we may receive the formal demonstration of fundamental differences between electrical and nervous vibrations, and have to admit that the latter possess special characters which differentiate them from all known classes of vibrations.

V.

I now come to a different order of facts, on which I will speak more fully, for I have to deal with my own researches, some, indeed, as yet unpublished. These I carried on in collaboration with M. André Broca; they are, I think, of a character likely to shed light on some of the conditions of the nerve-wave. True, they tell us nothing of the actual nature of nerve-vibration; but they will allow us to deduce the form of the nerve-wave.

Our experiments were made on the nerve-centres, not on the peripheral nerves; as a matter of fact, we believe that the laws which we have discovered for the one will apply to the other, and Charpentier's recent and most ingenious researches confirm this assimilation.

We must go back to the very definition of a vibration. We have seen that it is a movement of oscillation, an object is removed from a position of equilibrium and comes back to it again. Such is a *simple oscillation;* in a *complete wave*, after returning to the position of equilibrium from the furthest point, it passes that position and only returns after a certain traverse in the opposite direction.

If we call the first simple oscillation from the position of equilibrium the *positive phase*, the second oscillation is regarded as the *negative phase* of the complete wave. Now the phenomenon is no simple one; the return to equilibrium is not

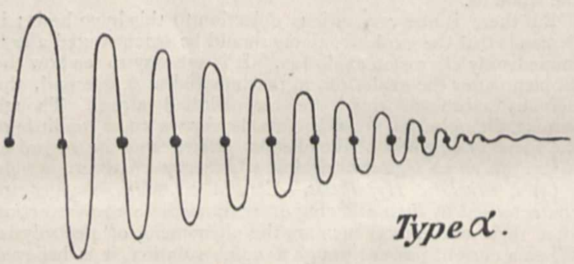


FIG. 1.

durable, and if no new condition intervene the vibration will continue. Were there no friction or resistance the vibration would persist indefinitely; for there is no reason for the motion to stop, and the pendulum, to take the very simplest case, would never return to rest at its original position of stable equilibrium. To stop the vibration there must be some deadening or *damping* process.

Physicists have studied the modes of damping, and find that they are divided into three types.

Type α is that of a pendulum, a vibrating string, or the waves of liquid when a stone enters the water. A series of complete waves follow with smaller and smaller oscillations, and the vibration dies out by the gradual decrease of the waves—secondary, tertiary, &c.—which followed the primary wave. This type of damping is, as we have said, due to the resistance of the medium consuming part of the energy; for, theoretically, a vibration once started would never stop. You are familiar with the fact that a pendulum continues to swing much longer in vacuo than in the air, and I need not dwell further on this point (Fig. 1).

Type β shows a very different character in its damping. After the pendulum has completed its first phase and passed the point of equilibrium, it meets a certain obstacle to its return point; it only swings back again very slowly thereto, and on reaching it it cannot pass beyond it. Indeed, from diverse theoretical considerations it may be proved that it never returns absolutely to the point of equilibrium; it approaches it indefinitely without ever reaching it; in short, ABA' is an asymptotic curve of which AA' is the asymptote. Later on we shall see what conclusions may be drawn from this as to the nature of the nerve-wave. Suffice it now to demonstrate the form of the wave with this type of damping. Practically, stable equilibrium is reached sooner than by type α: indeed, this is the type of damping used in the transmission of signals by submarine cables; where it is necessary to prevent each signal from producing a whole series of swings of the galvanometer needle, and to obtain as rapidly as possible its return to equilibrium and rest (Fig. 2).

Type γ remains to be described: here the pendulum, after being moved from the point of equilibrium, returns only very slowly to that position; this it does, for example, when hanging in a very dense medium. In this type of damping, as in β, there are no consecutive secondary and tertiary vibrations; nay, more, the damping is here so complete that there is no negative phase, only a simple oscillation. This curve is also asymptotic, and the return never reaches the primitive state of equilibrium (Fig. 3).

We see at once that the form of the wave is determined in each case by the type of its damping, and our experiments have

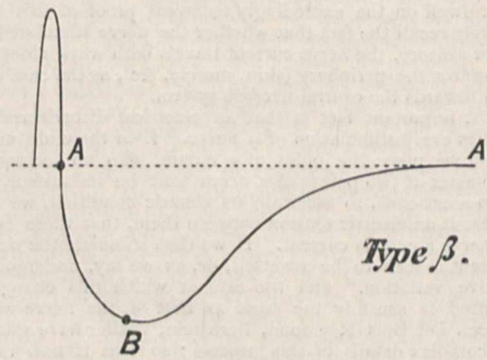


FIG. 2.

enabled us to determine the character of the damping of the nerve-wave. We might have set type α aside *à priori;* it would have been unreasonable to suppose it. If to wave 1 succeeded waves 2, 3, 4, &c., a single stimulus would produce a whole series of responses; now this is not the case with the nerve. Hence the damping must be on the type of β or of γ. But obvious as these considerations are when once stated, we did not reach them *à priori;* it required actual experience to enlighten us; so true is it that in science, at least in physiological science, experiment is more fertile than dialectic.

VI.

The following were the methods by which we determined the form of the nerve-wave. I will not describe our research in order of time; I shall only select some of the simplest, the most demonstrative, experiments. We know that but rarely are the earlier experiments one or the other; they are complex and

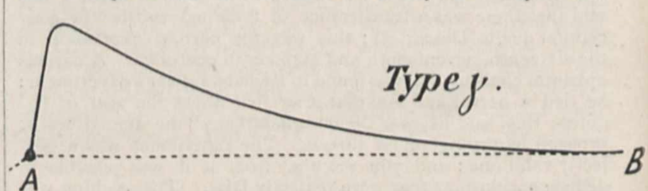


FIG. 3.

slow, and it is only by degrees that one learns how to simplify them and make them direct.

A dog is anæsthetised by the injection of a sufficient dose of chloralose into the veins (0·1 gramme to the kilo. of live weight), and electrodes are applied to the surface of its head. We can now observe the effects of an electric stimulus on the cerebral cortex under excellent conditions. The electrodes can be fixed immovably, so that the same part of the cortex is always stimulated; and the effects of the stimulus are always localised in the same muscles. If we repeat the same electric stimulus, supplied by a secondary current from accumulators, always of the same suitable intensity, we find that each successive electric shock, repeated at intervals of one second, calls forth a regular and equal muscular contraction in response. This regularity is complete, and if the conditions of circulation and respiration are kept satisfactory for one, two, or even three hours, we have a series of regular contractions which are easy to register. But when we quicken up the succession of the stimuli, there comes a time when the responsive contractions lose their regularity: a normal contraction is followed by a small one, a large one by a small one, and so on. Thus we can determine at what rate of intermission of the successive stimulations their responses lose their regularity: we find that when the intervals between the induction shocks are less than the tenth of a second, at the normal temperature of the body (39° C. for the dog) the contractions are no longer regular. Matters now go on just as if, after the large normal contraction, there were a *refractory period*, during which the excitability of the nervous system is lowered.

Marey, in his beautiful researches on the heart, had previously showed that after a contraction of the heart there is a short refractory period during which it is not excitable. So, after the stimulation of the brain, a period not exceeding 1/10″ intervenes during which it is not excitable, a refractory period.

Whatever be the temperature of the animal under experiment, we always find this refractory period, which, however, becomes easier to measure when the temperature falls, for then it lengthens out enormously. It is 0·1″ at 39° C.; 0·18″ at 35° C.; and if we chill the dog greatly, to 30° C., it rises to 0·6″. Hence it is advantageous to chill warm-blooded animals for the purpose of these observations.

It is noteworthy that this refractory period can be demonstrated otherwise than by electrical stimuli; mechanical shocks will also serve the purpose. If we poison a dog with chloralose, it becomes extremely sensitive to every mechanical disturbance. The least jolt of the table on which it lies makes it start, and though insensible, and not susceptible to pain, it responds to every jolt by a start. We can register these starts; and if, working with a dog cooled to 30°, we repeat the jars at intervals of less than half a second, the starts lose their regularity. Under these conditions a big start is followed by a small one, and *vice versâ*, though the jolts of the table are quite equal. In successful experiments we may even find the second shock absent; so that if the times of the successive jolts be noted as a, a^1, a^2, a^3, a^4, &c., we only get responsive shocks at a, a^2, a^4, &c.

The physicists have given the mathematical and mechanical explanation of this phenomenon, which they call the "*synchronisation of the oscillators*"; it has recently formed the subject of an important memoir by Cornu, which, however, I cannot describe even in abstract here. Suffice it to say that these refractory intervals presuppose the existence of a refractory period, of a *negative phase* in the nerve-wave.

The synchronisation of the nervous oscillation with that of the stimulus can only be explained by the assumption of the vibration of an apparatus (the nervous apparatus) possessing a proper period of its own, and with which we regulate and adjust the proper period of a second apparatus (the stimulating apparatus).

Thus, by this method we have succeeded in determining the duration of the nerve-wave; and we may state that this is 1/10″, an exceedingly slow rate as compared with electric or luminous vibrations, whose period is measured in 1-one thousand millionths or billionths of 1″.

We can also determine the form of the wave, and we find it approximate to our type β. If we consider the period of 0·1″ which elapses between the stimulus and the completion of the nerve-wave, we find that it may be divided into two periods: (A) in the first part a second simulus will augment the effect; it is the "*phase of summation*" or *positive phase* of the wave. (B) in the second period the stimulus produces a decreased effect; this is the "*phase of subtraction*" or *negative phase*. Now the phase of summation is very small, scarcely more than 0·01″, while the phase of subtraction is very long, nearly 0·09″; but I must not go into more detail on this point, lest I should enter on matters too strictly technical, which I prefer to avoid.

VII.

In cold-blooded animals the phenomena are quite different; and recent experiments have shown us how imprudent it would have been to generalise too hastily. If, indeed, we repeat the experiment on a tortoise, we find results apparently contradictory of those I have just related to you. A stimulus following another always appears to produce a stronger response than its predecessor. *There is no refractory period, there is a summation phase all the time*. Of course I mean that the stimuli must not be too far apart; if the interval exceeds 2″, two successive stimulations of the brain call forth equal contractions. But with intervals of less than 2″ summation phenomena are always observed, the more marked as the interval between successive stimuli is decreased. Finally, as I say, there is no refractory period.

Hence we may conclude that in cold-blooded animals (at least in the tortoise) the nerve-wave has a different form from that of the dog; after the displacement from the primitive position of equilibrium there is only a slow and gradual return, without any such backward oscillation as explains the negative phase in the dog. This form of wave we have described under the third type of damping (type γ) (Fig. 3).

This type of wave is exceedingly slow; if the tortoise be chilled by the use of suitable stimuli, we can estimate its duration at 2″. But with normal animals at 15° C. the period may perhaps be taken as 1″.

This difference of tenfold is not surprising; there was no antecedent improbability in conceiving that the nervous phenomena of a tortoise are ten times as slow as those of a dog.

VIII.

The fact that the nerve-wave lasts one-tenth of a second in the dog, as it probably does approximately in man, opens up a field of interesting considerations which confirm the results of direct experimental physiological observation.

If the nerve-wave lasts 1/10″, it follows that two nerve-waves cannot remain completely dissociated when they follow at shorter intervals than this. Suppose that a stimulus of light calls forth a nervous reaction, a sensation; this reaction, this sensation, will last at least one-tenth of a second; and consequently when a fresh stimulus follows on the first, its sensory response will not be clearly distinct unless this interval at least separates the two. If they follow more closely, they will blend together. Well, a classical and well-known experiment tells us that we cannot receive more than ten or eleven distinct retinal sensations in a second. At eleven per second, we already experience *flickering*; that is, the images are becoming confused. This, the persistence of retinal images, is the familiar principle of the cinematoscope, which has latterly received such elegant popular applications on a large scale.

No such exact studies have been made on the confusion of acoustic or tactile stimuli. But the very remarkable and concordant results of retinal sensation are enough to prove that the cerebral vibration consequent on a stimulation of the retina has a period of 1/10″.

If we turn to the case of a voluntary movement, determined also by a cerebral nerve-wave, we find the same figure. Schäfer in 1886 determined that distinct successive muscular contractions, voluntary or called forth (as reflexes) by electrical stimuli, very rarely exceeded 11–12 per second. Herringham found a frequency of 9–12 in pathological tremors. In the case of shivering from cold, I have determined frequencies of 10, 11, 12, 13 per second. Griffiths determined a frequency of 10 for the muscles of the thumb, and 14 for those of the arm. The Swedish physiologist, Lovèn, found that the electric oscillations of the cord determined by very frequent stimuli were only 8–10 per second.

Yet we know that if muscles be stimulated directly by rapidly alternating currents, they will contract with much greater frequency. The numerous physiologists who have studied the subject are agreed that we may thus determine as many as thirty or forty muscular contractions per second. If then we can only produce some ten voluntary contractions in the time, the cause lies, not in the muscles, but in the cerebral apparatus, which cannot vibrate more rapidly. Its period is 0·1″; it can only vibrate ten times in a second—can only order ten distinct voluntary movements of the same muscle in a second. It is not that the muscle cannot obey, but that the central nervous system cannot give its orders at a greater speed.

Now I will give you an experiment that you can all try for yourselves, which proves most clearly that the vibration of the nerve-centres determining a psychological phenomenon lasts about one-tenth of a second. When I thought over the various modes of obtaining a very rapid muscular motion, it occurred to me that perhaps the best was the articulation of some sentence pronounced with the greatest possible rapidity. We may admit that every syllable articulated represents a distinct muscular contraction, and consequently a distinct effort of the will. On trying what was the greatest speed of articulation, I found it was eleven syllables a second; and, indeed, at this speed all the syllables were not perfectly articulated.

This experiment has no particular interest in itself, for it only confirms the results of Schäfer, Lovèn and Griffiths, that repeated voluntary muscular actions have a speed of some ten or twelve per second. But, if we modify it slightly, its bearings are much wider. If instead of *vocally* articulating the syllables, we *think* them and articulate them only *mentally*, we exclude muscular action from any share in the process, and the rapidity of the mental articulation will be the index of the cerebral rhythm, not the muscular. Well, I found, as any of you can do with the help of a good seconds watch, that the mental articulation gives exactly the same figure as the vocal; that is, ten or eleven syllables per second.

We come to the interesting and relatively unforeseen conclusion that the cerebral phenomena of feeling (in the retina), volition (on the muscles), and thought (in mental articulation) cannot be repeated faster than twelve per second, and that they last about one-eleventh, or in round numbers one-tenth, of a second; the isolated sensation, the isolated act of will, the isolated intellectual process, have all the same minimum duration.

Placing this result next to our determination of the period of the nerve-wave, we conclude that there is here more than a mere coincidence; it is an *à posteriori* proof of our hypothesis as to the period of the nerve-wave.

From the psychological point of view this leads us to very important deductions. Of course we can conceive the second to be divided into hundredths, millionths, billionths; but these divisions have no relation to our direct consciousness. Our consciousness can only perceive much longer intervals. Our cerebral organisation determines narrow limits for our appreciation of time. We may therefore define the *psychological unit of time*, the irreducible unit, as *that minimum duration of time which is appreciable to our intelligence.* This is, indeed, susceptible of further theoretical subdivision; but such subdivisions correspond to no real mental image.

We may say, in other words, that the minimum time which our consciousness can directly apprehend is, in round numbers, one-tenth of a second.

"Swift as thought" is an everyday phrase; but you see thought is not very swift, after all, if we compare it to the enormous frequency of the vibrations of light and electricity.

Sir William Crookes, one of your most illustrious presidents, spoke of the relativity of our knowledge in his recent address; he alluded to the cruel imperfections of our animal nature. For us there exists no time-interval shorter than one-tenth of a second; and yet during this short interval, within which our gross intellectual apparatus cannot penetrate, who knows what sequences of phenomena may go on, which we could perceive if our nervous system had a shorter period of vibration? Then would phenomena which we perceive as continuous reveal their true character of discontinuity; those molecular vibrations which to us do not appear as vibrations would take on their real aspects. In a word, our time-unit, which is so different from the units of many phenomena of matter, makes us live in one perpetual illusion.

One more point I wish to touch upon is interesting in many respects. Let us come back to the diagram I gave you above to show the mode of damping of the nerve-wave. I told you that the original level is never regained when the system is damped to a position of rest; it approaches the level indefinitely but never reaches it. Practically speaking, equilibrium is reached at the end of the tenth of a second; physically and physiologically speaking, everything is set in order; the nerve-wave is ended, and the return to equilibrium is total. But if we deal with infinitesimal quantities this return is not complete; so that if we imagine an apparatus capable of appreciating infinitesimal quantities, it would show that, as the mathematical theory predicts, the return to equilibrium is never complete or absolute.

Well! we may fairly suppose that consciousness is alive to this infinitely small quantity, and that the impossibility of the complete return to the primitive equilibrium accounts for the strange phenomenon, unknown in the inorganic world, which we call *Memory*.

After a nerve-wave, the neuron is no longer in the same state as before; it retains the memory of the wave, and this makes it now other than what it was. I pronounce the vowel "A"; one-tenth of a second later I can pronounce some other vowel, for my nervous system has returned to equilibrium; but this return, however, is not complete, for the memory of the "A" which I pronounced persists, and will persist indefinitely. The primitive condition will never recur, whatever happens. In time the memory of the vowel "A" will gradually fade, but it will never be effaced. A nerve-wave of the brain is never completely extinguished.

The fact is that we are here on the confines of two totally distinct worlds: the world of physics and the world of psychology. What is infinitesimally small in the physical world may possibly be infinitely great in the psychological world. The residues of nerve-waves, the asymptotic prolongations of curves, may be neglected by the physiologist and the physicist; they are not negligible to consciousness.

Consciousness distinguishes them from the strong vibrations actually going on, which it recognises as "the present"; but the waves that are passed still exist for consciousness, never perhaps to be annihilated.

Assuredly this is but an hypothesis, perhaps an analogy, a comparison, rather than an hypothesis; but it is none the less interesting to note how far the physiological theory of the damping of the nerve-wave is in agreement with the grand psychological fact of memory, which it is scarcely possible to explain in any other way.

IX.

Thus the nerve-wave in its form and period, and in the mode of its damping, is comparable with the various waves of the unbounded universe in which we live, move and have our being. But this resemblance must not lead us away from the recognition of the abyss that separates the nerve-wave from all the other phenomena within our reach. The vibrations of the forces scattered about us are—at least with the greatest probability—blind phenomena, which know not themselves, which are the slaves of irresistible fatality. The nerve-wave, on the contrary, knows and judges itself; it is self-knowing or self-conscious; it can distinguish itself from the world which surrounds it and shakes it.

Since it possesses intelligence—for intelligence and consciousness are synonymous terms—it is susceptible of perfectibility; it is capable of right reasoning and of wrong reasoning; it can attain a moral ideal forbidden to those brute forces which follow their fated course; it can conceive the idea of truth and justice when it is a question of defending the innocent, of establishing brotherhood among men.

Consciousness, intelligence, the making for higher perfection—these are characters that have nought in common with the characters of other waves; they seem to be phenomena of another, a higher order. This vibration, whose physical conditions we have studied, enters into the domain of morals; and this fact establishes its essential difference from all other vibrations.

Assuredly the prodigiously rapid and regular undulations of light, and of electricity, appeal right justly to our admiration; but nothing is so admirable as this disturbance of the nerve-cell, which is self-knowing, self-judging, self-transforming, which strives to amend itself, and which from the stimuli which strike it can deduce some of the laws ruling the vast universe distinct from it. The nerve-wave of man—himself the last result of evolution—is the most perfect term of the things and of the beings which it is given to us to know.

Vast as is the world, mighty as are the fires of the infinite stars, the intelligence of man is of a higher order than these; and I would fain exclaim with the great philosopher, Immanuel Kant: "More than the starry heaven above my head, one thing fills me with admiration: the moral law in the heart of man."

ZOOLOGY AT THE BRITISH ASSOCIATION.

ON the opening day (Thursday) only the President's address was taken, and the Section then adjourned with the object of hearing addresses in other Sections which were of biological interest. The total number of papers brought before the Section this year was not as large as usual, but they extended over a wide range of zoological subject-matter, as the following outline programme shows:—

Friday morning, morphological papers; Friday afternoon, papers on entomology and mimicry; Saturday, marine biology; Monday, morphology, &c.; Tuesday, papers on sea-fishery questions. The usual reports upon investigations in progress were also submitted.

The morphological papers on Friday were as follows:—

(1) J. J. Lister, on *Astrosclera willeyana*, the type of a new family of calcareous sponges. This remarkable new sponge was brought home by Dr. A. Willey from Lifu in the Loyalty Islands. It has a continuous calcareous skeleton formed by the union of numerous polyhedral spicules to form a branched mass, between which run the soft parts with the system of canals. There are very minute ciliated chambers, and the ciliated cells do not appear to have the usual collars.

(2) Prof. Johnson Symington, on the morphology of the cartilages of the monotreme larynx. The thyroid cartilage of the monotremes (*Ornithorhynchus* and *Echidna*) agrees with that of the higher mammals in consisting of a single cartilaginous mass, but differs in the details and relations of its anterior and posterior cornua. Both the ontogeny and the phylogeny of the mammalian epiglottis support the view that it is a single median structure, and not, as Gegenbaur supposed, the result of fusion of two lateral elements.

(3) N. Bishop Harman, the palpebral and oculo-motor apparatus in fishes. Seventy species of fishes were examined. The simplicity or complexity were not found to agree with differentiation in phylogeny, nor with any scheme of classification, nor in relation to habitat. The source of the complex musculature of the eyelids of Selachians was traced to the branchial musculature of the spiracle, and this was further shown by the inverse ratio existing between the condition of spiracle and nictitating membrane. In those fish in which the latter is at its highest development the spiracle is absent, and *vice versâ*. The condition of the orbital sac, of the supporting rod of cartilage, of the eye-muscles, and of other neighbouring structures in the eyes of various groups of fishes was discussed.

(4) Prof. R. J. Anderson, on the pelvic symphysial bone of the Indian elephant; and a few notes on rhythmic motion.

(5) C. Dawson and S. A. Woodhead, on the crystallisation of beeswax, and its influence on the formation of the cells of bees.

On Saturday, when some of the zoologists from the French Association visited the Section, a few papers on marine biology likely to prove interesting for joint discussion were taken. Mr. W. Garstang brought forward a first report on the periodic investigation of the plankton and physical conditions of the English Channel during 1899. These investigations have been carried out at regular quarterly intervals during the year, from a steam-tug; and the observations were made at certain fixed localities along lines between Plymouth and Ushant, from Ushant towards the 100 fms. line, and off the entrance to the Channel. Observations of the water temperature (with deep-sea reversing thermometers) at various depths, and of the salinity (with Mill's water-bottle) of the water were taken; and collections of plankton were made with an effective closing tow-net specially devised by Mr. Garstang to replace the pump and hose method, which had proved unsatisfactory. This new net, and also that of Dr. C. G. J. Peterson for the quantitative estimation of plankton, were on exhibition and with the rest of the apparatus were shown working. Mr. Garstang's investigations in the Channel are not yet completed, and two further series of observations are still to be made. The record so obtained will be of high value in both marine biological and hydrographical inquiry. Prof. Lankester and others took part in the discussion, and one of the visitors, Baron Jules de Guerne, explained the somewhat similar observations he had been making from the Prince of Monaco's yacht *Princesse Alice*, and described the closing nets he employed. The reports upon the Naples and Plymouth biological stations were also submitted.

On Monday the following papers were taken:—

(1) J. Graham Kerr, the development of *Lepidosiren paradoxa*; and a note on the hypothesis of the origin of the vertebrate paired limbs. Mr. Kerr had been sent by the University of Cambridge with an expedition in search of *Lepidosiren* to the rivers and swamps of Gran Chaco in Paraguay; and he gave an interesting summary of the life-history of this important type.

(2) Dr. J. F. Gemmill, on negative evidence regarding the influence of nutrition in determining sex. Dr. Gemmill shows that certain fixed species of marine animals are under very different conditions of nutrition from the very earliest period, according as they are high or low on the shore, and yet the proportions of the sexes remain unchanged—indicating that in such forms nutrition has no effect in determining sex.

(3) F. P. Morena and A. Smith Woodhead, exhibition of and remarks on a skull of the extinct Chelonian *Miolania* from Patagonia, along with an exhibition of newly-discovered *Neomylodon* remains from Patagonia—a most interesting and important exhibit of these remarkable remains.

(4) G. E. H. Barrett-Hamilton, the fur seals of the Bering Sea. An account of their habits and condition.

The rest of the afternoon was occupied with reports of Committees, which will be noticed below.

On Tuesday, Sir John Murray read a paper on Dr. Peterson's experiments in the Cattegat, with the marking and measuring of plaice in order to determine distribution and growth, and on plaice culture in the Limfjord. By transplanting young fish from the North Sea into the richer feeding grounds of the shallow fjord, it was found that from April to November they increased to five times their original weight. The cost of transportation was one-sixth of a penny per fish, and the price obtained for a fish so fattened was 4*d.*—a notably successful attempt at economic fish culture.

Mr. W. Garstang gave an account o. his experiments at Plymouth on the artificial rearing of young sea-fish. In this Mr. Garstang has, so far, been very successful; and has succeeded in rearing about 50 per cent. of his larvæ through their critical stages to the complete adult organisation. They are fed on plankton, and are kept in "plunger" jars with not more than five larvæ to a gallon of water.

Dr. James Murie gave an account of the Thames Estuary: its physico-biological aspects as bearing upon its fisheries. These papers gave rise to some discussion on marine fish-culture.

Prof. McIntosh, finally, gave a paper on the occurrence of the grey gurnard (*Trigla gurnardus*, L.), and its spawning in inshore and offshore waters. He shows by a monthly examination of the statistics that this important fish does not begin to move into the inshore waters for spawning purposes until after February, and attains its maximum in May. He does not consider that a maximum as late as August in some years can be taken to indicate a second spawning migration, as supposed by the Scottish Fishery Board. Spawning goes on from April to September.

The Reports of Committees submitted to the Section were as follows:—

(1) The Naples Zoological Station.—The British Association table has been occupied by Dr. H. Lyster Jameson, who gives a summary of his work upon the anatomy of certain Gephyrea and allied vermiform organisms. The usual statistics and other information in regard to the station during the year are also given.

(2) Investigations at the Plymouth Marine Laboratory.—This contains two short papers, one on the embryology of the Polyzoa, by T. H. Taylor, and the other on the rearing of larvæ of Echinidæ, by Prof. MacBride. Mr. Taylor's observations were made on the larvæ of *Bowerbankia*, which he successfully carried through their fixation and metamorphosis on strips of celloidin. MacBride found at Plymouth that the larvæ of Echinids would only live in pure water brought from outside the breakwater. He discusses the difficulties, and the conditions necessary for successful rearing of larvæ.

(3) Zoology and Botany of the West India Islands.—This is the final report, and consists of a list of the publications of the Committee. The material which still remains unworked out has been presented to the British Museum.

(4) Zoology of the Sandwich Islands.—This ninth report shows what has been published by the Committee during the year, and gives the plans for further exploration in the Islands in conjunction with the Honolulu Museum.

(5) Bird Migration in Great Britain and Ireland.—The labour of working out the numerous records obtained from lighthouse-keepers is still being continued by Mr. Eagle Clarke, and a conclusive report is not yet possible.

(6) Zoological and Botanical Publication.—The Secretary of the Committee is in correspondence with editors of academical and periodical publications, and the results will be reported on at a future meeting.

(7) Index animalium.—This great piece of work is still being carried on by Mr. Sherborn, who has indexed about 1500 volumes during the last year. The first section of the Index, dealing with 1758–1800, will soon be ready for publication.

(8) Pedigree Stock Records.—This report is drawn up by Dr. Francis Galton, and deals with the production of photographs, under standard conditions, of prize-winners at shows of pedigree stock, in order to have exact trustworthy records of ancestry.

(9) A circulatory apparatus for experimental observations on marine organisms.—The work has been carried out by Mr. F. W. Gamble at the Piel Sea-Fish Hatchery on the Lancashire coast; and the observations chiefly dealt with the changes in colour, and the mechanism of colour physiology in the Crustacean *Hippolyte varians*.

On one of the afternoons Mr. J. W. Woodall took a small party of zoologists to sea in his yacht *Vallota*, to witness the trial of Mr. Garstang's new tow net, which can be opened and closed in any depth of water. In addition to the actual proceedings in Section D, it may be noted that there was a good deal in several of the other Sections that was of zoological interest.

THE SEVENTH INTERNATIONAL GEOGRAPHICAL CONGRESS.

AT the close of the Sixth International Geographical Congress in London in 1895 it was decided that the next meeting should be held in Berlin in 1899, under the auspices of the Berlin Geographical Society. This meeting, with its attendant festivities, has just been concluded. Although the actual sittings of the Congress extended only from September 28 to October 4, the proceedings began a week earlier and were continued more than a week later, by a series of geographical excursions to different parts of the German Empire. Taken as a whole the Congress must be pronounced not only successful, but brilliantly so; it presents a sort of climax in respect of grandeur to the preceding meetings, and suggests that the time has now come for reconsidering the general plan of such gatherings, and starting afresh on lines of plainer living, if not of higher thinking. Here, however, we have only to sketch the work of the Congress just over, not to suggest the plan of its successor.

The Council of the Berlin Geographical Society had the entire charge of the organisation, and by the usage of previous meetings the President of the Society, Baron Ferdinand von Richthofen, professor of Geography in the University of Berlin, was President of the Congress. The personal efforts of Baron Richthofen were unceasing before and during the meeting, and as no German geographer is better known or more widely respected at home and abroad, the accident of his presidency of the Society was singularly fortunate for the success and *éclat* of the Congress. He was supported as secretary by Hauptmann Georg Kollm, and a number of younger geographers who formed a staff of efficient assistant secretaries, but whose names were not brought before the members. Similarly, the various honorary officials—vice-presidents, members of committees, &c., whose names had appeared in circulars sent out some months before the meeting—remained unknown to most of the members, who had left their early circulars at home. There were general programmes, printed in German, English and French, detailing the work for each day, and a supplementary programme of entertainments in German only, with additions and alterations to the list of papers; but there was no daily journal giving a clear view of the work of each day, with the names of presiding officers and a summary of the work of the day before, as at the London Congress. German also was the one language used in the general business, all announcements were made in German only, almost all the notices exhibited were in German and sometimes even in the German script, which can scarcely be looked on as an international character. In London the three languages were used for every written or printed notice and every important verbal announcement. The abstracts of papers, which were circulated daily, were printed in the language of the author only. The foreigner, unversed in the German language and unused to German customs, was somewhat at a disadvantage throughout, both in scientific meetings and at social functions.

These minor matters apart, the organisation left nothing to desire. The grand building of the Prussian Chamber of Deputies, generously lent to the Congress by the Prussian Government, formed a perfect home for the member. A "depositorium," bearing the number of his ticket, received all communications intended for him, an admirably-conducted cloak-room relieved him of hat and coat, and restored them with a swiftness and certainty that seemed magical to the frequenter of British scientific gatherings; a vast refreshment room could serve breakfast, lunch and supper to the whole Congress simultaneously; picture post-cards (more essential than food to the German visitor) were on sale in every room, even in the Great Hall while papers were being read; desks were provided for issuing tickets, badges and the many offerings of books, maps, &c., presented by institutions and firms; while the luxurious reading- and writing-rooms of the Prussian Deputies were thrown open absolutely without reserve. As an example of international hospitality, the installation of the Congress was memorable and unique. Perhaps the best managed of all the hospitable arrangements was the Ladies' Committee, specially charged with the care of the lady associates of the Congress, which carried out its work with most satisfactory diligence and completeness.

The Congress commenced informally in true German style by the members dropping in as they arrived on the evening of Wednesday, September 27, to the restaurant of the House of Deputies, where they sat at supper or wandered through the various halls, greeting old friends and forming new acquaintances. Next morning at ten o'clock the formal opening took place with much dignity, the gentlemen appearing in evening dress or uniform with a profuse display of orders. Prince Albrecht of Prussia welcomed the Congress in the name of the Emperor; Prince Hohenlohe, the Imperial Chancellor, welcomed it in the name of the Empire; Herr Studt, the new Prussian Minister of Education, in the name of the kingdom of Prussia, the speeches of these great personages being received in solemn silence. The Burgermeister of Berlin then welcomed the members in the name of the city, and applause, which was not stinted to subsequent speakers, then began. The welcome was responded to by a few of the most distinguished foreigners. Baron Richthofen read his presidential address, on the progress of geography in the nineteenth century; Sir Clements Markham, as president of the sixth Congress, gave a short address, resigning his office and presenting the report of the London Congress. Vice-presidents and chairmen of the different sections were nominated, and the formalities were over.

It is unnecessary to detail the social accompaniments of the Congress. The Imperial Chancellor gave a small dinner and a large reception to the foreigners and the more prominent German members. The city of Berlin gave an admirably conducted dinner to the whole Congress in the Zoological Gardens. The Berlin Geographical Society also entertained all the members to a reception and supper, and there was a special performance in the Opera House.

It is impossible to pass without remark the magnificent hospitality of Hamburg, where over 500 members of the Congress were received by the local Geographical Society, and carried through two days of uninterrupted festivity. The Senate opened the State rooms of the new Town Hall, probably the finest municipal building in the world, for the first time in honour of the visitors, and an even more impressive view of the vast wealth and activity of the greatest continental seaport was afforded by a cruise through the harbour and a visit to the floating docks and ship-building works. The Hamburg-America Line entertained a thousand guests to lunch in the "'tween-decks" of the *Pretoria*, said to be the largest cargo steamer afloat, and this on the day before she sailed for New York with a full cargo and complement of passengers. No less hearty and no less interesting were the receptions accorded to the members of the various excursions to the Baltic shores, the Rhine and Central Germany by the local authorities and geographical societies.

The serious business of the Congress was divided into a general meeting in the forenoon from ten to one, and three simultaneous meetings in the afternoon, commencing at two o'clock, and sitting until five or even six. A time-limit for speakers was formally announced, but rarely, if ever, enforced; and the system of allowing one speaker to address the meeting as often as he liked on the same subject led to the degeneration of some of the debates into long-winded dialogues.

The programme with its additions bore the titles of no less than 150 papers, many of which were intended to be introductory to discussions. This number might have been reduced with great advantage. A few were the work of "cranks," a good many were old or of no international interest; but the great majority were new and valuable and deserving of far more complete discussion than their number made it possible for them to receive.

The departments of Geography which received most attention at the Congress were, perhaps, Antarctic Exploration, Oceanography and Plant-Geography. Dr. Erich von Drygalski gave a detailed account of the plans for the German Antarctic expedition, which is to sail in 1901, and submitted the specifications for the ship and her equipments. All the preparations for the expedition are in a forward state. Dr. Drygalski himself is the scientific leader, the captain of the ship being simply a sailing-master responsible for the navigation. Dr. Vanhöffen, who accompanied Dr. Drygalski in his Greenland expedition, goes as botanist, and several other members of the scientific staff, which will number at least six, have been chosen. Much stress is laid on the importance of co-operation with the British expedition. Dr. Drygalski hopes to land somewhere to the south of Kerguelen, that island being occupied by a land-party as a scientific base, and to advance towards the South Pole by the aid of dogs. Sir Clements Markham gave a full exposition of the plans of the British expedition. He said that the vessel for the expedition will be built of oak with an ice-casing of harder wood. She will be 172 feet long by 33 broad, with a displacement of about 1525 tons. Arrangements will be made for a magnetic observatory before the mainmast, which shall have no iron within 30 feet of it. There will be accommodation for six executive officers, including two engineers, three civilians for biology and geology, including the surgeon, and thirty-nine men. Melbourne will be the base for magnetic observations, and a party will be landed in MacMurdo Bay, near Mount Erebus, to push inland with sledges, but without dogs, the use of which involves unjustifiable cruelty. In the discussion on the Antarctic papers, Dr. Nansen strongly defended the use of dogs, the alternative being in his opinion far greater cruelty to men. Sir John Murray urged the importance of circumpolar oceanographical investigations as a preliminary to the penetration of the Antarctic ice-pack. M. Arçtowski read a paper on the oceanographical and meteorological results of the *Belgica's* voyage, and Prof. Nielsen of Christiania gave some account of Sir George Newnes' expedition under Mr. Borchgrevink.

In north polar exploration the most important papers were the first public statements regarding the scientific results of the *Fram* expedition. Dr. Nansen in a lecture of an hour and a half's duration described the North Polar Basin as revealed by his soundings, and discussed the distribution of temperature and the circulation of water in it in great detail, while Prof. Mohn in another paper gave a *résumé* of the meteorological results. It is impossible in a few lines to summarise either of these massive contributions to knowledge.

Oceanographical papers were numerous, that of Prof. Chun, the leader of the *Valdivia* expedition, exciting the greatest amount of interest. Sir John Murray discussed the distribution of deep-sea deposits over the ocean floor, and the Prince of Monaco described some of the results of his recent cruise to Spitsbergen. Several useful and really international discussions took place, culminating in the appointment of committees to draw up a systematic terminology and nomenclature for the forms of sub-oceanic relief, introduced by Profs. Wagner, Krümmel, Voiekoff and Dr. H. R. Mill, and to determine a common method of expressing the density of sea-water, introduced by Baron Wrangell and Prof. Pettersson.

There were several valuable papers on subjects involving climatology, limnology, the study of glaciers and seismology, and one on kumatology by Mr. Vaughan Cornish; indeed it would be difficult to mention any department of physical geography to which some contribution was not made.

The geography of plants was discussed with particular thoroughness, both with regard to the distribution of special types of vegetation and the more general relations of nomenclature and cartographic representation. Profs. Drude, Engler, Warburg, Krasnoff and Nehring dealt with these subjects.

The geological aspects of geography produced several papers of unusual value, including one by Prof. de Lapparent on the question of peneplains, one by Prof. Penck on the deepening of alpine valleys, and one by Mrs. Gordon (Dr. Maria Ogilvie) on the basins of southern Europe. Mr. W. Obrucheff, of St. Petersburg, gave an important account of the orography and tectonic structure of the trans-Baikal region of Siberia as revealed by the most recent observations—between 1895 and 1898; and Prof Philippson discussed the Ægean region in a similar way.

The human and historical aspects of geography were not left in the background. Prof. Ratzel discoursed on the origin and dispersal of the Indo-Germanic peoples, and Prof. Sieglin on the discovery of England in ancient times. Papers were read on the need of fresh organisation in obtaining statistics of population in unorganised countries by Dr. Scott Keltie, and on means of representing such statistics on maps by Prof. Hettner. Prof. Neovius, of Helsingfors, exhibited a remarkable atlas of Finland recently completed by the Finnish Geographical Society, in which all the conditions of the land, natural and economic, are mapped with a completeness that has never been attempted for any other country. It even includes a map showing in horse-power the available energy of the rivers.

As was to be expected there were many papers on geography in its educational aspects. Amongst these one by Prof. Ratzel on geographical position as the central fact in geographical education was perhaps the most important.

The last meeting of the Congress was to have been addressed by Prof. Hergesell on the results of international balloon investigations, but the author somewhat rashly made an ascent the previous morning in a balloon, which carried him so far towards the Russian frontier that the Congress had been formally closed before the slow means of terrestrial locomotion brought him back to Berlin.

No better bird's-eye view of the work of the Congress can be given than by presenting in a condensed form the series of resolutions passed at the final meeting, which are intended to minister to more complete international co-operation in the work of scientific investigations.

RESOLUTIONS OF THE SEVENTH INTERNATIONAL GEOGRAPHICAL CONGRESS.

(The order is that in which the resolutions were presented.)

(1) The Congress appoints a Committee of Bio-geographers resident in or near Berlin to draw up a uniform scheme of nomenclature for plant-formations, and after consultation with non-resident specialists, to revise the same and present it to the Eighth Congress.

(2) The Congress believes that the plans for international co-operation in Antarctic exploration form an excellent basis for joint research in physical geography, geology, geodesy and biology. With regard to meteorological and magnetic work, however, they appoint an international committee to determine the general scheme and methods to be employed on the expeditions, and to endeavour to organise a system of simultaneous observations in the regions surrounding, but exterior to, the Antarctic.

(3) The Congress expresses the earnest desire that all maps, including those published in countries using English and Russian measures, should, in addition to the graphic scale, bear the proportion of lengths on the map to those in nature in the usual form $1:x$.

(4) The Congress views it as desirable that the publication of all new geographical material accompanying accounts of travel, should be supported by details regarding the methods of surveying, the instruments employed, and their verification, the calculation of astronomical positions with their probable error, and the method of utilising these data in preparing the map. Also that all maps published by scientific men, institutions or governments should be accompanied by notes of the principal fixed points.

(5) The Congress expresses the hope that a uniform system of measures will be used in all geographical researches and discussions, and recommends that the metric system of weights and measures be so employed.

(6) The Congress expresses the hope that in scientific publications the centigrade thermometer scale should, as far as possible, be employed; or, at least, the values in centigrade degrees added to those expressed on the scales of Fahrenheit or Réaumur.

(7) With regard to the proposal to introduce a decimal division of time and angles, the Congress desires to preserve the present division of time and of the circumference into 360°, but allows that the adoption of a different subdivision of the angle might be studied, and considers that in certain cases the decimal subdivision of the degree of arc presents no objection.

(8) The Congress is of opinion that the *Bibliotheca Geographica*, published by the Berlin Geographical Society, may be accepted as an efficient international bibliography of geography.

(9) The Congress considers the construction of statistical population maps to be very desirable, and appoints an international committee to draw up a scheme, at the same time expressing the hope that national committees will be formed in various countries to promote the preparation of such maps.

(10) The Congress considers the collection of data as to the

distribution of floating ice to be very important, and appeals to the hydrographic and meteorological institutes of the countries whose ships frequent high latitudes to induce the masters of vessels to keep a regular record of the occurrence of drifting ice. The Congress believes that the Danish Meteorological Institute in Copenhagen is the best adapted as an international centre for collecting the records.

(11) The Congress nominates an international committee to consider the nomenclature of the floor of the ocean, and to produce and publish at latest in time for the next Congress a chart of the ocean with revised nomenclature.

(12) The Congress hopes that the names of oceanic islands, especially in the Pacific, will be revised with a view to ascertaining and preserving the native names. Where no native names exist or can be ascertained, the names given by the discoverers should be used. The arbitrary changing of established names ought to be opposed by every means.

(13) The Congress recognises the desirability of obtaining data for a more exact estimate than now exists of countries in which there is no means of taking a census, and desires to bring the matter to the notice of such Governments as have foreign possessions.

(14) The Congress expresses sympathy with the proposal to equip an expedition in New South Wales, with the sole object of endeavouring to discover remains or traces of the route of the Leichhardt expedition, which perished in the interior of Australia fifty-two years ago.

(15) The Congress is favourable to the foundation of an international seismological society, and appoints an international committee for the study of earthquakes.

(16) The Congress believes the production of a map of the world on the scale of 1 : 1,000,000, the sheets bounded by meridians and parallels, to be both useful and desirable. The Permanent Bureau of the Congress is instructed to deal with the question, and in the first instance to secure the preparation of a projection for the map with degree-lines on the determined scale.

(17) The Congress considers the establishment of an International Cartographical Association of service, and appoints a committee to take preliminary steps.

THE SCIENTIFIC CONFERENCE AT WIESBADEN.

WE refer in a leading article to one of the most important developments of scientific organisation which our time has seen. The proceedings at a recent conference at Wiesbaden, dealing with this matter, are thus stated in Monday's *Times*:—

"For several years past there has existed an Association or Cartell of the Academies of Sciences of Munich and Vienna and of the Royal Societies of Sciences of Göttingen and Leipzig, which has met yearly to discuss matters of common interest, and the combined action of these bodies has in several ways been fruitful of results. Representatives of the Royal Society of London attended the meeting held last year at Göttingen, as well as that which took place the previous year at Leipzig, chiefly with the object of discussing the project of an international catalogue of scientific literature which the society has been engaged in promoting.

"When the invitation was conveyed to the Royal Society of London to send representatives to the Göttingen meeting it was intimated that the Cartell would be glad to learn the views of the society as to the possibility of its joining the association. The delegates appointed from London were instructed to state that the Royal Society would be disposed to join provided that the organisation were so extended as to assume a truly international character. This suggestion was not only accepted in principle at Göttingen, but it was agreed that the Royal Society of London should be requested to take the steps, if thought desirable, to ascertain how far the establishment of such an international association would commend itself to the leading scientific bodies of other countries.

"The Royal Society of Sciences of Berlin, although not included in the Cartell, has for several years past been represented at its meetings. When the Royal Society of London had ascertained that the project was likely to find favour it was agreed that the Royal Society and the Berlin Academy should together issue an invitation to the Academy of Science, Paris, the Imperial Academy of Sciences, St. Petersburg, the Reale Accademia dei Lincei, Rome, the National Academy, Washington, U.S.A., as well as to the bodies included in the Cartell, requesting them to send delegates to a conference to be held in Wiesbaden on the 10th and 11th of this month.

"At the conference, excepting the Reale Accademia dei Lincei, which was unable to send delegates, although in full sympathy with the movement, all the bodies invited were represented—the Berlin Academy by Messrs. Auwers, Virchow and Diels; the Göttingen Society by Messrs. Ehlers and Leo; the Leipzig Society by Messrs. Windisch and Wislicenus; the Royal Society by Messrs. Rücker, Armstrong and Schuster; the Munich Academy by Messrs. von Zittel Dyck and von Sicherer; the Paris Academy by Messrs. Darboux and Moissan; the St. Petersburg Academy by Messrs. Famintzine and Salemann; the Washington Academy by Messrs. Newcomb, Remsen and Bowditch; and the Vienna Academy by Messrs. Mussafia, von Lang, Lieben and Gomperz.

"Prof. Auwers, one of the secretaries of the Berlin Academy, occupied the chair, and the success of the meeting was largely due to the extreme ability and tact, combined with judicious firmness, with which he conducted the proceedings. Besides showing himself a master of the three languages—German, French and English—used in the debates, he was thoroughly informed on every point which came up for discussion. Fortunately, all the delegates appeared to be actuated by the desire to co-operate, and there was little difficulty in framing statutes which all were prepared to accept.

"The immediate outcome of the conference has been that it is resolved to found an international union of the principal scientific and literary bodies of the world, the object of which will be to initiate or promote scientific enterprises of general interest recommended by one or more of the associated bodies, and to facilitate scientific intercourse between different countries. It is to be known as the International Association of Academies. A number of important bodies besides those represented at Wiesbaden are to be invited to join. General meetings of delegates from the various constituent academies are to take place, as a rule, at intervals of three years, but the interval may be varied and special meetings held if necessary. The Royal Society had proposed, prior to the conference, that the first general meeting should be held in Paris next year. At the general meetings two sections will be constituted, one dealing with mathematics and the natural sciences, the other with arts and philosophy.

"A council is to be appointed which will carry on the business in the intervals between meetings. The formation of committees of experts to initiate and promote scientific investigations of international importance is also contemplated.

"It remains to be mentioned that the Berlin Academy had also arranged for the entertainment of the delegates at the close of the debates. On the Monday evening they were invited to attend a performance of Lortzing's opera *Undine*, and on the Tuesday they were entertained at dinner in the Kurhaus. On the latter occasion Prof. Virchow occupied the chair, and opened the proceedings by toasting the delegates generally; he was followed by Prof. Darboux, of Paris, who proposed the health of the Berlin Academy. In the course of the evening, in characteristic German style, every other possible toast was proposed by one or other of the delegates.

"It is to be hoped that when the statutes framed at the conference are communicated to the various bodies interested they will meet with approval, and that the establishment of the organisation will soon be an accomplished fact. In times when political feeling is so strongly developed the provision of a common platform on which all nations can meet amicably and co-operate in furthering scientific enterprises must prove of the very greatest value; and if the spirit of amity which prevailed at the conference be extended to future meetings the success of the association is assured."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Sir Michael Foster has been reappointed a manager of the Balfour Fund for zoological research.

Mr. Yule Oldham, reader in geography, is giving three courses of lectures this term: (1) on the Geography of Europe, for history students; (2) on Physical Geography; and (3) on the History of Geographical Discovery.

The degree of M.A. honoris causa is to be conferred on Dr. Somerville, the recently-elected Professor of Agriculture.

Mr. W. N. Shaw, F.R.S., is reappointed Assistant-Director of the Cavendish Laboratory.

Prof. D. J. Cunningham, F.R.S., of Dublin, is appointed an Elector to the chair of Anatomy, and Prof. W. F. R. Weldon, F.R.S., of Oxford, an Elector to the chair of Zoology, in succession to the late Sir W. H. Flower.

Dr. D. MacAlister, of St. John's College, has been re-elected a representative of the University on the General Medical Council for five years.

Fifteen candidates have passed the recent examination in sanitary science, and have thus qualified for the Diploma in Public Health.

THE destruction of the Technical Institute at West Ham by a fire which occurred on Monday night, and was first discovered in the chemical laboratory, is a disaster to technical education in London. The Institute commenced a short time ago an admirable programme of work in science and technology, and as it was the only municipal technical institute in the metropolitan area, its career has been closely followed. The damage done is estimated at over 80,000*l.*, only part of which is covered by insurance.

THE systematic study of geography is so much neglected in this country that it is to be hoped the School of Geography recently established at Oxford will be successful. During the present term Mr. H. J. Mackinder, the University Reader in Geography, will lecture on the historical geography of the British Isles. The lecturer in physical geography (Mr. Dickson) will lecture on the climate of the British Isles. The assistant to the Reader (Dr. Herbertson) will lecture on the geomorphology of Europe; and the lecturer in ancient geography (Mr. Grundy) will lecture on the general historical topography of Greece. Dr. Herbertson will give instruction in cartography and practical geography, with field work; and during the term special attention will be given to the study of map projections, and of physical maps of all kinds.

ANOTHER addition to the laboratory equipment of our public schools has recently been made at Felsted, where new buildings for the teaching of science were opened last week. The laboratory consists of a lecture room with raised seating and a gallery, the lecture table being provided with down draught and electricity for experimental purposes, and behind it a faced wall surface for the lantern. The chemical laboratory is a room about thirty feet square to accommodate twenty-six boys, and has an adjoining balance room. In addition there is a general physical laboratory for a like number of boys, a special laboratory for senior physics, an optical room, store room and workshop. The building is in a large measure a gift of one of the governors of the school, and has been erected under the direction of Mr. A. E. Munby. It was opened by Dr. Garnett, of the London County Council, who gave an address on science as a means of general education. Sir John Gorst recently visited the building and expressed his warm approbation of the arrangements.

PRACTICAL science in rural districts, as a means of benefiting British agriculture, has, we are glad to observe, received much support lately. The meeting of the Agricultural Education Committee, held at the Society of Arts on Friday last, showed the existence of a strong feeling that active efforts should be made to secure systematic and efficient instruction, both theoretical and practical, in agricultural subjects suitable to every class engaged in agriculture; and to diffuse among the agricultural classes a more thorough appreciation of the advantages of instruction bearing directly or indirectly on their industry. The chairman, Sir William Hart Dyke, explained that the province of the committee, as a united body, was to bring pressure upon Parliament and upon public opinion to establish in rural schools rational courses of instruction bearing upon agricultural pursuits. The following resolutions were subsequently adopted:—(1) That, in the proposed organisation of the new Board of Education, due regard should be had to the interests of agricultural instruction. (2) That proper provision should at once be made at certain of the Teachers' Training Colleges for giving to those who desire it both theoretical and practical instruction in subjects bearing on agriculture and horticulture. (3) That, after a certain date to be named in next year's code, instruction in the elementary branches of natural science bearing on agriculture should be made compulsory in rural elementary schools, and that such instruction should be accompanied and illustrated by experiments, and (where possible) by practical work in plots of ground attached to the schools. (4) That county authorities be encouraged to provide experimental and school farms, and to contribute, by scholarships and otherwise, to some agricultural college or department of the first rank. The realisation of the conditions expressed in these resolutions should be desired by every one interested in national progress.

SCIENTIFIC SERIAL.

Wiedemann's Annalen der Physik und Chemie, No. 9.—Dispersion of gypsum, by W. König. The author studies the dispersion of gypsum in the visible spectrum by observing the influence of wave-length upon the width of interference fringes produced by means of wedges made of that material.—Electric charge of freshly-prepared electrolytic gases, by W. Kösters. Hydrogen and oxygen are positively electrified by passing through sulphuric acid, and this may help to explain the positive charge of the same gases when produced by electrolysis. In other cases, however, the gases passed through a liquid do not assume the same electrification as when generated by electrolysis.—Further experiments with Becquerel rays, by J. Elster and H. Geitel. Thinking that the radiation of uranium and thorium compounds might be influenced by the impact of kathode rays, the authors exposed a piece of Joachimsthal pitchblende to kathode rays, but they could not trace any influence of the rays. The authors believe the Becquerel rays to be Röntgen rays of small intensity. They support this view by showing that they are not deflected by a magnet (see p. 623).—Radioactive baryta and polonium, by F. Giesel. The author describes the preparation of the radio-active barium salts. He has not yet succeeded in isolating the active principle, whether radium or polonium.—Canal and kathode rays, by P. Ewers. The writer does not share the prevalent opinion that canal rays consist of projected anode particles, since the quantity of electricity conveyed by them varies with the material of the kathode, but not with that of the anodes. He concludes that the canal rays consist of positive ions of the material of the kathode, but the matter thus conveyed to the wall is so small that it would require 288 hours of continuous working to deposit one milligramme of aluminium.—Law of development of Hittorf's dark space, by H. Ebert. Hittorf's dark space is the narrow space which immediately adjoins the luminous kathode layer. Its width increases as exhaustion proceeds, and does so in accordance with a geometrical series when the pressure diminishes in another geometrical series. The indices of the series are, however, generally different.—Magnetic susceptibilities of inorganic compounds, by S. Meyer. Judging from their compounds, the rare elements lanthanum, cerium, praseodymium, samarium, gadolinium, and especially erbium, must be strongly magnetic. Erbium oxide is four times as strongly magnetic as Fe_2O_3, and if the conclusion as to their bases is correct, erbium must be, weight for weight, six times as strongly magnetic as iron. This would have an important practical signification if erbium were to be found in large quantities.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 16.—M. van Tieghem in the chair.—On the positions of equilibrium of a ship carrying liquid cargo, by M. Appell. The author develops a problem of M. Guyou, giving a means of finding the positions of equilibrium and discussing their stability.—Method of setting a collimator, by M. G. Lippmann. The slit is observed with an auxiliary telescope, and between this and the collimator a biplate is inserted. In general two images of the slit are observed, but on adjusting the collimating lens, at one point the two images coincide; the rays issuing from the collimator are now parallel. The accuracy of the adjustment is limited only by the resolving power of the telescope.—Production of ozone by the decomposition of water with fluorine, by M. Henri Moissan. A rapid current of fluorine, prepared in a copper apparatus, is passed into water kept at 0°. The ozonised oxygen thus set free was carefully analysed by treatment with potassium iodide and measuring the iodine set free. The percentage of ozone was on one occasion as high as 14·4 per cent., and this preparation, although somewhat delicate, is not costly. The ozone produced in this way is absolutely free from all trace of oxides of nitrogen, and may possibly have industrial applications.—The preventive qualities of the blood serum of an immunised heifer against contagious peripneumonia in cattle, by MM. S. Arloing and Duprez. The direct inoculation for peripneumonia suggested by M. Willems has two disadvantages: some time is required to develop the protective effects, and occasionally fatal tumours occur. A heifer was directly inoculated with gradually increasing amounts of venom until it became capable of resisting a dose five hundred times greater than would be sufficient to kill an unprotected animal. The serum of this heifer was used in the experiments, which were not altogether conclusive, since one of the injected animals caught the disease, whilst another, although unprotected, escaped.—Report on an earthquake at Smyrna on September 20, by the French Consul General at Smyrna.—Observations of the Giacobini Comet (September 29, 1899), made at the Observatory of Algiers, with the equatorial of 31·6 cm. aperture, by MM. Rambaud and Sy.—On a problem relating to the congruences of right lines, by M. E. Goursat.—On the classification of projective groups in space of *n* dimensions, by M. F. Marotte.—Theory of the number of roots of an algebraic equation comprised in the interior of a given circumference, by M. Michael Petrovitch.—On the reactions of induction of alternators, by M. A. Blondel.—Experiments in telegraphy without wires, carried out between Chamonix and the summit of Mont Blanc, by MM. Jean and Louis Lecarme. The communications were interfered with by the ice, or by the absence of water in the soil; neither were the effects of atmospheric electricity sufficient to stop the messages, but during the time the electric light at Chamonix was in action working was impossible.—Radiographic bulb with a cold antikathode, by MM. Abel Buguet and Victor Chabaud. The platinum tube forming the antikathode is fused directly to the glass, and is kept cool by cold water. Very powerful discharges from large induction coils can be used with this tube without any heating of the platinum resulting.—On a new radio-active material, by M. A. Debierne. A new radio-active substance has been isolated from pitchblende. It is distinguished from polonium and radium by its chemical properties, which resemble titanium very closely, and also by the fact that it is not spontaneously luminous. The rays emitted by this substance, for which no name is as yet suggested, are about 100,000 times stronger than those given off by uranium. They render gases capable of discharging electrified bodies, excite the phosphorescence of barium platinocyanide, and affect photographic plates.—On the atomic weight of boron, by M. Henri Gautier. The author, after reviewing the earlier work of Berzelius, Abrahall, and Ramsay and Aston, attempts to prepare compounds of boron of the constancy of composition of which there can be no doubt, and selects the sulphide B_2S_3 and carbide B_6C for a preliminary study.—On anhydrous magnesium carbonate, by M. R. Engel.—On the heat of oxidisation of tungsten, by MM. Delépine and Hallopeau. The usual methods of combustion at ordinary pressure, combination with a halogen, attack by water or acid having failed for tungsten, the method of burning in the calorimetric bomb was tried, and after some preliminary experiments was found to give good results, the mean value per gram of tungsten being 1062 calories. In forming the oxides TuO_2 and TuO_3, each atom of oxygen has nearly the same calorific value.—Action of potassium-ammonium upon arsenic, by M. C. Hugot. With the alkaline ammonium in excess, AsK_3 is formed; with arsenic in excess, As_4K_2.—Action of bromine in presence of aluminium chloride upon some chloro-benzenes, by M.M. A. Mouneyrat and Ch. Pouret. Bromine acts readily upon chlorobenzene in presence of aluminium chloride, and gives an excellent yield of *p*-bromo-chlorbenzene. The following compounds have been obtained by this method: C_6Br_5Cl, [1, 4] $C_6Br_4Cl_2$, [1, 2, 4] $C_6Br_3Cl_3$, [1, 2, 4, 5] $C_6Br_2Cl_4$, and $C_6Br_4Cl(CH_3)$.—On the constitution of the colouring matter of leaves; chloroglobin, by M. Tsvett.—Demonstration of the disaggregation of leucocytes and the solution of their contents in the blood plasma during hypoleucocytosis. Influence of intravascular leucolysis on the coagulation of the blood, by M. Henri Stassano.—Germination of the seed of the carob; production of mannose by a soluble ferment, by MM. Ed. Bourquelot and H. Hérissey. During the germination of the carob seed there is soluble ferment produced, which acts upon the stored albumen similarly to diastase upon amylaceous albumens, mannose and galactose being the products.—On *Aplosporidium*, a new order of the class of Sporozoa, by MM. Maurice Caullery and Félix Mesnil.—Calcified suberous layers from the coal measures of Hardinghen, by M. C. Eg. Bertrand.—On the composition and food value of the principal fruits, by M. Balland.—Submarine lithology of the coasts of France, by M. J. Thoulet.

DIARY OF SOCIETIES.

THURSDAY, OCTOBER 26.

CAMERA CLUB, at 8.15.—Illusions and Anomalies of Vision: Shelford Bidwell, F.R.S.

FRIDAY, OCTOBER 27

PHYSICAL SOCIETY, at 5.—The Magnetic Properties of the Alloys of Iron and Aluminium: Dr. S. W. Richardson.—Exhibition of a Model illustrating a Number of the Actions in the Flow of an Electric Current: G. L. Addenbrooke.—Repetition of some Experiments with the Wehnelt Interrupter devised by Prof. Lecher: W. Watson

INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—The Incrustation of Pipes at Torquay Water Works: William Ingham.—A Continuous Mean-Pressure Indicator for Steam Engines: Prof. William Ripper.

WEDNESDAY, NOVEMBER 1.

ENTOMOLOGICAL SOCIETY, at 8.—Exhibition of Lepidoptera from Bulgaria: H. J. Elwes, F.R.S., and Mrs. Nicholl.

SOCIETY OF PUBLIC ANALYSTS, at 8.—The Meaning of the Acetyl Value in Fat Analysis (with Lantern Illustrations): Dr. J. Lewkowitsch.

THURSDAY, NOVEMBER 2.

LINNEAN SOCIETY, at 8.—On the Proliferous State of the Awn of Nepal Barley: Rev. Prof. Henslow.—On the Hyobranchial Skeleton and Larynx of the New Aglossal Toad, *Hymenochirus Boettgeri*: Dr. W. G. Ridewood.—On the Eye-spot and Cilium in *Euglena viridis*: Harold Wager.

CHEMICAL SOCIETY, at 8.—The Theory of Saponification: J. Lewkowitsch.—The Action of Dilute Nitric Acid on Oleic and Elaidic Acids: F. G. Edmed.—Tetrazoline: Siegfried Ruhemann and H. E. Stapleton.—On Ethylic Dibromobutanetetracarboxylate and the Synthesis of Tetrahydrofurfuran-*aa'*-dicarboxylic Acid: Dr. Bevan Lean.—(1) Camphoroxime. Part III. Behaviour of Camphoroxime towards Potassium Hypobromite; (2) Optical Influence of an Unsaturated Linkage on certain Derivatives of Bornylamine: Dr. M. O. Forster.

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