THURSDAY, FEBRUARY 5, 1880

CLERK-MAXWELL'S SCIENTIFIC WORK

At the instance of Sir W. Thomson, Mr. Lockyer, and others I proceed to give an account of Clerk-Maxwell's work, necessarily brief, but I hope sufficient to let even the non-mathematical reader see how very great were his contributions to modern science. I have the less hesitation in undertaking this work that I have been intimately acquainted with him since we were schoolboys together.

If the title of mathematician be restricted (as it too commonly is) to those who possess peculiarly ready mastery over symbols, whether they try to understand the significance of each step or no, Clerk-Maxwell was not, and certainly never attempted to be, in the foremost rank of mathematicians. He was slow in "writing out," and avoided as far as he could the intricacies of analysis. He preferred always to have before him a geometrical or physical representation of the problem in which he was engaged, and to take all his steps with the aid of this: afterwards, when necessary, translating them into symbols. In the comparative paucity of symbols in many of his great papers, and in the way in which, when wanted, they seem to grow full-blown from pages of ordinary text, his writings resemble much those of Sir William Thomson, which in early life he had with great wisdom chosen as a model.

There can be no doubt that in this habit, of constructing a mental representation of every problem, lay one of the chief secrets of his wonderful success as an investigator. To this were added an extraordinary power of penetration, and an altogether unusual amount of patient determination. The clearness of his mental vision was quite on a par with that of Faraday; and in this (the true) sense of the word he was a mathematician of the highest order.

But the rapidity of his thinking, which he could not control, was such as to destroy, except for the very highest class of students, the value of his lectures. His books and his written addresses (always gone over twice in MS.) are models of clear and precise exposition; but his *extempore* lectures exhibited in a manner most aggravating to the listener the extraordinary fertility of his imagination.

His original work was commenced at a very early age. His first printed paper, "*On the Description of Oval Curves, and those having a Plurality of Foci*," was communicated for him by Prof. Forbes to the Royal Society of Edinburgh, and inserted in the "*Proceedings*" for 1846, before he reached his fifteenth year. He had then been taught only a book or two of Euclid, and the merest elements of Algebra. Closely connected with this are three unprinted papers, of which I have copies (taken in the same year), on "*Descartes' Ovals*," "*The Meloid and Apioid*," and "*Trifocal Curves*." All of these, which are drawn up in strict geometrical form and divided into consecutive propositions, are devoted to the properties of plane curves whose equations are of the form

$$mr + nr' + pr'' + \ldots = \text{constant},$$

r, r', r'', &c., being the distances of a point on the curve from given fixed points, and m, n, p, &c., mere numbers. Maxwell gives a perfectly general method of tracing all such curves by means of a flexible and inextensible cord. When there are but two terms, if m and n have the same sign we have the ordinary Descartes' Ovals, if their signs be different we have what Maxwell called the Meloid and the Apioid. In each case a simple geometrical method is given for drawing a tangent at any point, and some of the other properties of the curves are elegantly treated.

Clerk-Maxwell spent the years 1847-50 at the University of Edinburgh, without keeping the regular course for a degree. He was allowed to work during this period, without assistance or supervision, in the Laboratories of Natural Philosophy and of Chemistry: and he thus experimentally taught himself much which other men have to learn with great difficulty from lectures or books. His reading was very extensive. The records of the University Library show that he carried home for study, during these years, such books as Fourier's *Théorie de la Chaleur*, Monge's *Géometrie Descriptive*, Newton's *Optics*, Willis' *Principles of Mechanism*, Cauchy's *Calcul Différentiel*, Taylor's *Scientific Memoirs*, and others of a very high order. These were *read through*, not merely consulted. Unfortunately no list is kept of the books consulted in the Library. One result of this period of steady work consists in two elaborate papers, printed in the *Transactions of the Royal Society of Edinburgh*. The first (dated 1849) "*On the Theory of Rolling Curves*," is a purely mathematical treatise, supplied with an immense collection of very elegant particular examples. The second (1850) is "*On the Equilibrium of Elastic Solids*." Considering the age of the writer at the time, this is one of the most remarkable of his investigations. Maxwell reproduces in it, by means of a special set of assumptions, the equations already given by Stokes. He applies them to a number of very interesting cases, such as the torsion of a cylinder, the formation of the large mirror of a reflecting telescope by means of a partial vacuum at the back of a glass plate, and the theory of Örsted's apparatus for the compression of water. But he also applies his equations to the calculation of the strains produced in a transparent plate by applying couples to cylinders which pass through it at right angles, and the study (by polarised light) of the doubly-refracting structure thus produced. He expresses himself as unable to explain the permanence of this structure when once produced in isinglass, gutta percha, and other bodies. He recurred to the subject twenty years later, and in 1873 communicated to the Royal Society his very beautiful discovery of the *temporary* double refraction produced by shearing in viscous liquids.

During his undergraduateship in Cambridge he developed the germs of his future great work on "Electricity and Magnetism" (1873) in the form of a paper "On Faraday's Lines of Force," which was ultimately printed in 1856 in the "Trans. of the Cam. Phil. Soc." He showed me the MS. of the greater part of it in 1853. It is a paper of great interest in itself, but extremely important as indicating the first steps to such a splendid result. His idea of a fluid, incompressible and without mass, but subject to a species of friction in space, was confessedly adopted from the analogy pointed out by

Thomson in 1843 between the steady flow of heat and the phenomena of statical electricity.

Other five papers on the same subject were communicated by him to the *Philosophical Magazine* in 1861–2, under the title *Physical Lines of Force*. Then in 1864 appeared his great paper "*On a Dynamical Theory of the Electromagnetic Field*." This was inserted in the *Philosophical Transactions*, and may be looked upon as the first complete statement of the theory developed in the treatise on *Electricity and Magnetism*.

In recent years he came to the conclusion that such analogies as the conduction of heat, or the motion of the mass-less but incompressible fluid, depending as they do on Laplace's equation, were best symbolised by the quaternion notation with Hamilton's ∇ operator; and in consequence, in his work on electricity, he gives the expressions for all the more important physical quantities in their quaternion form, though without employing the calculus itself in their establishment. I have discussed in another place (NATURE, vol. vii. p. 478) the various important discoveries in this remarkable work, which of itself is sufficient to secure for its author a foremost place among natural philosophers. I may here state that the main object of the work is to do away with "action at a distance," so far at least as electrical and magnetic forces are concerned, and to explain these by means of stresses and motions of the medium which is required to account for the phenomena of light. Maxwell has shown that, on this hypothesis, the velocity of light is the ratio of the electro-magnetic and electro-static units. Since this ratio, and the actual velocity of light, can be determined by absolutely independent experiments, the theory can be put at once to an exceedingly severe preliminary test. Neither quantity is yet fairly known within about 2 or 3 per cent., and the most probable values of each certainly agree more closely than do the separate determinations of either. There can now be little doubt that Maxwell's theory of electrical phenomena rests upon foundations as secure as those of the undulatory theory of light. But the life-long work of its creator has left it still in its infancy, and it will probably require for its proper development the services of whole generations of mathematicians.

This was not the only work of importance to which he devoted the greater part of his time while an undergraduate at Cambridge. For he had barely obtained his degree before he read to the Cambridge Philosophical Society a remarkable paper *On the Transformation of Surfaces by Bending*, which appears in their *Transactions* with the date March 1854. The subject is one which had been elaborately treated by Gauss and other great mathematicians, but their methods left much to be desired from the point of view of simplicity. This Clerk-Maxwell certainly supplied; and to such an extent that it is difficult to conceive that any subsequent investigator will be able to simplify the new mode of presentation as much as Maxwell simplified the old one. Many of his results, also, were real additions to the theory; especially his treatment of the *Lines of Bending*. But the whole matter is one which, except in its almost obvious elements, it is vain to attempt to popularise.

The next in point of date of Maxwell's greatest works is his "Essay on the Stability of the Motion of Saturn's Rings," which obtained the Adams' Prize in the University of Cambridge in 1857. This admirable investigation was published as a pamphlet in 1859. Laplace had shown in the *Mécanique Céleste* that a uniform solid ring cannot revolve permanently about a planet; for, even if its density were so adjusted as to prevent its splitting, a slight disturbance would inevitably cause it to fall in. Maxwell begins by finding what amount of *want* of uniformity would make a solid ring stable. He finds that this could be effected by a satellite rigidly attached to the ring, and of about 4½ times its mass:—but that such an arrangement, while not agreeing with observation, would require extreme artificiality of adjustment of a kind not elsewhere observed. Not only so, but the materials, in order to prevent its behaving almost like a liquid under the great forces to which it is exposed, must have an amount of rigidity far exceeding that of any known substance.

He therefore dismisses the hypothesis of solid rings, and (commencing with that of a ring of equal and equidistant satellites) shows that a continuous liquid ring cannot be stable, but may become so when broken up into satellites. He traces in a masterly way the effects of the free and forced waves which must traverse the ring, under various assumptions as to its constitution; and he shows that the only system of rings which can dynamically exist must be composed of a very great number of separate masses, revolving round the planet with velocities depending on their distances from it. But even in this case the system of Saturn cannot be permanent, because of the mutual actions of the various rings. These mutual actions must lead to the gradual spreading out of the whole system, both inwards and outwards:—but if, as is probable, the outer ring is much denser than the inner ones, a very small increase of its external diameter would balance a large change in the inner rings. This is consistent with the progressive changes which have been observed since the discovery of the rings. An ingenious and simple mechanism is described, by which the motions of a ring composed of equal satellites can be easily demonstrated.

Another subject which he treated with great success, as well from the experimental as from the theoretical point of view, was the Perception of Colour, the Primary Colour Sensations, and the Nature of Colour Blindness. His earliest paper on these subjects bears date 1855, and the seventh has the date 1872. He received the Rumford Medal from the Royal Society in 1860, "For his Researches on the Composition of Colours and other optical papers." Though a triplicity about colour had long been known or suspected, which Young had (most probably correctly) attributed to the existence of three sensations, and Brewster had erroneously[1] supposed to be objective, Maxwell was the first to make colour-sensation the subject of actual measurement. He proved experimentally that any colour C (given in intensity of illumination as well as in character) may be expressed in terms of three arbitrarily chosen standard colours, X, Y, Z, by the formula

$$C = aX + bY + cZ.$$

Here a, b, c are numerical coefficients, which may be

[1] All we can positively say to be erroneous is some of the principal arguments by which Brewster's view was maintained, for the subjective character of the triplicity has not been absolutely *demonstrated*.

positive or negative; the sign = means "matches," + means "superposed," and − directs the term to be taken to the other side of the equation.

These researches of Maxwell's are now so well known, in consequence especially of the amount of attention which has been called to the subject by Helmholtz' great work on Physiological Optics, that we need not farther discuss them here.

The last of his greatest investigations is the splendid Series on the Kinetic Theory of Gases, with the closely connected question of the sizes, and laws of mutual action, of the separate particles of bodies. The Kinetic Theory seems to have originated with D. Bernoulli; but his successors gradually reverted to statical theories of molecular attraction and repulsion, such as those of Boscovich. Herapath (in 1847) seems to have been the first to recall attention to the Kinetic Theory of gaseous pressure. Joule in 1848 calculated the average velocity of the particles of hydrogen and other gases. Krönig in 1856 (*Pogg. Ann.*) took up the question, but he does not seem to have advanced it farther than Joule had gone; except by the startling result that the weight of a mass of gas is only half that of its particles when at rest.

Shortly afterwards (in 1859) Clausius took a great step in advance, explaining, by means of the kinetic theory, the relations between the volume, temperature and pressure of a gas, its cooling by expansion, and the slowness of diffusion and conduction of heat in gases. He also investigated the relation between the length of the mean free path of a particle, the number of particles in a given space, and their least distance when in collision. The special merit of Clausius' work lies in his introduction of the processes of the theory of probabilities into the treatment of this question.

Then came Clerk-Maxwell. His first papers are entitled "Illustrations of the Dynamical Theory of Gases," and appeared in the *Phil. Mag.* in 1860. By very simple processes he treats the collisions of a number of perfectly elastic spheres, first when all are of the same mass, secondly when there is a mixture of groups of different masses. He thus verifies Gay-Lussac's law, that the number of particles per unit volume is the same in all gases at the same pressure and temperature. He explains gaseous friction by the transference to and fro of particles between contiguous strata of gas sliding over one another, and shows that the coefficient of viscosity is independent of the density of the gas. From Stokes' calculation of that coefficient he gave the first deduced approximate value of the mean length of the free path; which could not, for want of data, be obtained from the relation given by Clausius. He obtained a closely accordant value of the same quantity by comparing his results for the kinetic theory of diffusion with those of one of Graham's experiments. He also gives an estimate of the conducting power of air for heat; and he shows that the assumption of non-spherical particles, which during collision change part of their energy of translation into energy of rotation, is inconsistent with the known ratio of the two specific heats of air.

A few years later he made a series of valuable experimental determinations of the viscosity of air and other gases at different temperatures. These are described in *Phil. Trans.* 1866; and they led to his publishing (in the next volume) a modified theory, in which the gaseous particles are no longer regarded as perfectly elastic, but as repelling one another according to the law of the inverse fifth power of the distance. This paper contains some very powerful analysis, which enabled him to simplify the mathematical theory for many of its most important applications. Three specially important results are given in conclusion, and they are shown to be independent of the particular mode in which gaseous particles are supposed to act on one another. These are:—

1. In a mixture of particles of two kinds differing in amounts of mass, the average energy of translation of a particle must be the same for either kind. This is Gay Lussac's Law already referred to.

2. In a vertical column of mixed gases, the density of each gas at any point is ultimately the same as if no other gas were present. This law was laid down by Dalton.

3. Throughout a vertical column of gas gravity has no effect in making one part hotter or colder than another; whence (by the dynamical theory of heat) the same must be true for all substances.

Maxwell has published in later years several additional papers on the Kinetic Theory, generally of a more abstruse character than the majority of those just described. His two latest papers (in the *Phil. Trans.* and *Camb. Phil. Trans.* of last year) are on this subject:—one is an extension and simplification of some of Boltzmann's valuable additions to the Kinetic Theory. The other is devoted to the explanation of the motion of the radiometer by means of this theory. Several years ago (NATURE, vol. xii. p. 217), Prof. Dewar and the writer pointed out, and demonstrated experimentally, that the action of Mr. Crookes' very beautiful instrument was to be explained by taking account of the increased length of the mean free path in rarefied gases, while the then received opinions ascribed it either to evaporation or to a quasi-corpuscular theory of radiation. Stokes extended the explanation to the behaviour of disks with concave and convex surfaces, but the subject was not at all fully investigated from the theoretical point of view till Maxwell took it up. During the last ten years of his life he had no rival to claim concurrence with him in the whole wide domain of molecular forces, and but two or three in the still more recondite subject of electricity.

"Every one must have observed that when a slip of "paper falls through the air, its motion, though un"decided and wavering at first, sometimes becomes "regular. Its general path is not in the vertical direc"tion, but inclined to it at an angle which remains nearly "constant, and its fluttering appearance will be found to "be due to a rapid rotation round a horizontal axis. The "direction of deviation from the vertical depends on the "direction of rotation. . . . These effects are commonly "attributed to some accidental peculiarity in the form of "the paper. . . . " So writes Maxwell in the *Cam. and Dub. Math. Jour.* (May, 1854), and proceeds to give an exceedingly simple and beautiful explanation of the phenomenon. The explanation is, of course, of a very general character, for the complete working out of such a problem appears to be, even yet, hopeless; but it is thoroughly characteristic of the man, that his mind could never bear to pass by any phenomenon without satisfying itself of at least its general nature and causes.

In the same volume of the *Math. Journal* there is an exceedingly elegant "problem" due to Maxwell, with his solution of it. In a note we are told that it was "suggested by the contemplation of the structure of the crystalline lens in fish." It is as follows :—

A transparent medium is such that the path of a ray of light within it is a given circle, the index of refraction being a function of the distance from a given point in the plane of the circle. Find the form of this function, and show that for light of the same refrangibility—

1. The path of *every ray within the medium* is a circle.

2. All the rays proceeding from any point in the medium will meet accurately in another point.

3. If rays diverge from a point without the medium and enter it through a spherical surface having that point for its centre, they will be made to converge accurately to a point within the medium.

Analytical treatment of this and connected questions, by a novel method, will be found in a paper by the present writer (*Trans. R.S.E.* 1865).

Optics was one of Clerk-Maxwell's favourite subjects, but of his many papers on various branches of it, or subjects directly connected with it, we need mention only the following :—

"On the General Laws of Optical Instruments" (*Quart. Math. Jour.* 1858).

"On the Cyclide" (*Quart. Math. Journal*, 1868).

"On the best Arrangement for Producing a Pure Spectrum on a Screen" (*Proc. R.S.E.* 1868).

"On the Focal Lines of a Refracted Pencil" (*Math. Soc. Proc.* 1873).

A remarkable paper, for which he obtained the Keith Prize of the *Royal Society of Edinburgh*, is entitled "On Reciprocal Figures, Frames, and Diagrams of Forces." It is published in the *Transactions* of the Society for 1870. Portions of it had previously appeared in the *Phil. Mag.* (1864).

The triangle and the polygon of forces, as well as the funicular polygon, had long been known; and also some corresponding elementary theorems connected with hydrostatic pressure on the faces of a polyhedron: but it is to Rankine that we owe the full principle of diagrams, and reciprocal diagrams, of frames and of forces. Maxwell has greatly simplified and extended Rankine's ideas: on the one hand facilitating their application to practical problems of construction, and on the other hand extending the principle to the general subject of stress in bodies. The paper concludes with a valuable extension to three dimensions of Sir George Airy's "Function of Stress."

His contributions to the *Proceedings of the London Mathematical Society* were numerous and valuable. I select as a typical specimen his paper on the forms of the stream-lines when a circular cylinder is moved in a straight line, perpendicular to its axis, through an infinitely extended, frictionless, incompressible fluid (vol. iii. p. 224). He gives the complete solution of the problem; and, with his usual graphical skill, so prominent in his great work on Electricity, gives diagrams of the stream-lines, and of the paths of individual particles of the fluid. The results are both interesting and instructive in the highest degree.

In addition to those we have mentioned we cannot recall many pieces of *experimental* work on Maxwell's part:—with two grand exceptions. The first was connected with the determination of the British Association Unit of Electric Resistance, and the closely associated measurement of the ratio of the electrokinetic to the electrostatic unit. In this he was associated with Professors Balfour Stewart and Jenkin. The Reports of that Committee are among the most valuable physical papers of the age; and are now obtainable in a book-form, separately published. The second was the experimental verification of Ohm's law to an exceedingly close approximation, which was made by him at the Cavendish Laboratory with the assistance of Prof. Chrystal.

In his undergraduate days he made an experiment which, though to a certain extent physiological, was closely connected with physics. Its object was to determine why a cat always lights on its feet, however it may be let fall. He satisfied himself, by pitching a cat gently on a mattress stretched on the floor, giving it different initial amounts of rotation, that it instinctively made use of the conservation of Moment of Momentum, by stretching out its body if it were rotating so fast as otherwise to fall head foremost, and by drawing itself together if it were rotating too slowly.

I have given in this journal (vol. xvi. p. 119) a detailed account of his remarkable elementary treatise on "Matter and Motion," a work full of most valuable materials, and worthy of most attentive perusal not merely by students but by the foremost of scientific men.

His "Theory of Heat," which has already gone through several editions, is professedly elementary, but in many places is probably, in spite of its admirable definiteness, more difficult to follow than any other of his writings. In intrinsic importance it is of the same high order as his "Electricity," but as a whole it is *not* an elementary book. One of the few knowable things which Clerk-Maxwell did not know, was the distinction which most men readily perceive between what is easy and what is hard. What *he called* hard, others would be inclined to call altogether unintelligible. In the little book we are discussing there is matter enough to fill two or three large volumes without undue dilution (perhaps we should rather say, *with the necessary dilution*) of its varied contents. There is nothing flabby, so to speak, about anything Maxwell ever wrote: there is splendid muscle throughout, and an adequate bony structure to support it. "Strong meat for grown men" was one of his favourite expressions of commendation; and no man ever more happily exposed the true nature of the so-called "popular science" of modern times than he did when he wrote of "the forcible language "and striking illustrations by which those who are past hope "of being even beginners [in science] are prevented from "becoming conscious of intellectual exhaustion before "the hour has elapsed."

To the long list of works attached to Maxwell's name in the Royal Society's Catalogue of Scientific Papers may now be added his numerous contributions to the latest edition of the "Encyclopædia Britannica"—Atom, Attraction, Capillarity, &c. Also the laborious task of preparing for the press, with copious and very valuable original notes, the "Electrical Researches of the Hon. Henry Cavendish." This work has appeared only within a month or two, and contains many singular and most unexpected revelations as to the early progress of the science of electricity. We hope shortly to give an account of it.

The works which we have mentioned would of themselves indicate extraordinary activity on the part of their author, but they form only a fragment of what he has published; and when we add to this the further statement, that Maxwell was always ready to assist those who sought advice or instruction from him, and that he has read over the proof-sheets of many works by his more intimate friends (enriching them by notes, always valuable and often of the quaintest character), we may well wonder how he found time to do so much.

Many of our readers must remember with pleasure the occasional appearance in our columns of remarkably pointed and epigrammatic verses, usually dealing with scientific subjects, and signed $\frac{dp}{dt}$.[1] The lines on Cayley's portrait, where determinants, roots of -1, space of n dimensions, the 27 lines on a cubic surface, &c., fall quite naturally into rhythmical English verse;—the admirable synopsis of Dr. Ball's Treatise on Screws;—the telegraphic love-letter with its strangely well-fitting *volts* and *ohms;* and specially the "Lecture to a Lady on Thomson's Reflecting Galvanometer," cannot fail to be remembered. No living man has shown a greater power of condensing the whole marrow of a question into a few clear and compact sentences than Maxwell shows in these verses. Always having a definite object, they often veiled the keenest satire under an air of charming innocence and *naïve* admiration. Here are a couple of stanzas from unpublished pieces of a similar kind:—first, some ghastly thoughts by an excited evolutionist—

To follow my thoughts as they go on,
Electrodes I'd place in my brain;
Nay, I'd swallow a live entozöon,
New feelings of life to obtain——

next on the non-objectivity of Force—

Both Action and Reaction now are gone;
Just ere they vanished
Stress joined their hands in peace, and made them one,
Then they were banished.

It is to be hoped that these scattered gems may be collected and published, for they are of the very highest interest, as the work during leisure hours of one of the most piercing intellects of modern times. Every one of them contains evidence of close and accurate thought, and many are in the happiest form of epigram.

I cannot adequately express in words the extent of the loss which his early death has inflicted not merely on his personal friends, on the University of Cambridge, on the whole scientific world, but also, and most especially, on the cause of common sense, of true science, and of religion itself, in these days of much vain-babbling, pseudo-science, and materialism. But men of his stamp never live in vain; and in one sense at least they cannot die. The spirit of Clerk-Maxwell still lives with us in his imperishable writings, and will speak to the next generation by the lips of those who have caught inspiration from his teachings and example.

P. G. TAIT

[1] This *nom de plume* was suggested to him by me from the occurrence of his initials in the well-known expression of the second Law of Thermodynamics (for whose establishment on thoroughly valid grounds he did so much) $\frac{dp}{dt}$ = J. C. M.

CENTRAL AMERICAN BIOLOGY

Biologia Centrali-Americana; or, Contributions to the Knowledge of the Fauna and Flora of Mexico and Central America. Edited by F. Duncane Godman and Osbert Salvin. 4to. Zoology, Parts 1 and 2, 1879. Botany, Parts 1 and 2, 1879. (London, 1879, published for the Editors by R. H. Porter, 10, Chandos Street, Cavendish Square, W.)

TWENTY years ago the Natural History of Central America was almost unknown to us. With the exception of a few stray papers in periodicals—most of them of ancient date—the student had no means of becoming acquainted with the many rich and rare forms of life which are found in that part of the Neotropical Region. Mexican and Central American specimens were scarcely found in our museums, and were looked upon as the greatest rarities. Within recent years all this has been changed. Naturalists and collectors have ransacked every part of the Central-American Isthmus, from the frontiers of the United States down to the Panama Railway, and though, no doubt, much remains to be done, the fauna and flora of this district are perhaps, on the whole, better explored than those of any other part of th region to which they belong.

It is to one of the authors of the work now before us, more than to any other person, we believe, that this great change in our knowledge of the fauna and flora of Central America is due. Mr. Osbert Salvin first became interested in the plants and animals of Guatemala more than twenty years ago, when he was induced by the example of the late Mr. George Ure Skinner—a name well known to collectors of orchids and humming-birds, to visit this district and to explore the verdant forests of Vera Paz. Since that period Mr. Salvin has made three other journeys to Central America—accompanied on one of these occasions by his friend and fellow-labourer, Mr. Godman. Besides that, the joint collection of Central American birds and butterflies amassed by these two gentlemen, has been largely increased by the aid of native collectors employed in various parts of the Panamanic sub-region, while mammals and reptiles from the same sources have been furnished to the British Museum, and series of plants to the Royal Herbarium at Kew. Numerous papers contributed by Messrs. Salvin and Godman themselves, or by fellow-workers upon materials furnished by them to the *Ibis*, the *Proceedings* of the Zoological Society, the *Annals* of Natural History, and other periodicals, testify to the success that has rewarded their efforts, not only as regards the discovery of new forms, but also as to the better knowledge of many which were previously but little known.

After twenty-two years' labour on the particulars our authors have wisely determined that the time is come when they may safely undertake a general work upon this extensive subject. Under the title of "Biologia Centrali-Americana" they accordingly propose to publish a series of quarto volumes, of which the first four numbers are now before us. These volumes will contain a series of essays upon the Fauna and Flora of Mexico and Central America, from the valleys of Rio Grande and Rio Gila, on the north, down to the Isthmus of Darien on the south—being the area embraced in what Mr. Sclater, we believe, has called the Panamanic or Transpanamanic division of his Neotropical Region. For the better perfecting of this great undertaking, the editors have wisely confined their own labours to the birds and butterflies, to which they have given their principal attention. In other groups they have obtained the assistance of their brother naturalists, and have, we must say, shown great qualifications for the editorial portion of their work, by making a very judicious selection of contributors.

Mr. E. R. Alston, well known as a most efficient contributor to the *Zoological Record*, has undertaken the mammals. For the part devoted to the reptiles, amphibians, and fishes, the valuable services of Dr. Günther have been secured; while for the land and fresh-water molluscs, our editors have gone as far as Berlin, whence Dr. E. von Martens has promised to give them his most efficient assistance. The crustaceans, or at least a small but particularly interesting division of them, have found a friend nearer home, in the person of Prof. Huxley, with whom we all know the Malacostraca are one of his pet subjects. The Arachnida have been assigned to the Rev. O. Pickard-Cambridge; whilst the various groups of insects have been undertaken by different experts, amongst whom we notice the names of Mr. Bates, Mr. McLachlan, and Mr. Wood-Mason. The botanical portion has been placed in the hands of Mr. W. B. Hemsley, late of the Royal Herbarium of Kew.

So much for the plan of the present work, which, when complete, will form, it is estimated, as many as twelve or thirteen volumes of 500 pages, although the authors, being still in constant receipt of additional collections, do not bind themselves to restrict their labours even to this liberal allowance. Let us now turn over the parts already issued, and see in what style they have commenced their somewhat ambitious undertaking.

The two zoological parts contain the commencement of the essays on the mammals by Mr. Alston; on the Birds, by Messrs. Salvin and Godman; on the Butterflies, by the same gentleman; and on the Longicorn Coleoptera, by Mr. Bates. All these groups, if we understand it rightly, are proposed to be treated of in nearly the same manner. Taking Mr. Alston's contribution for an example, we find the commencement of a complete account of the mammals hitherto ascertained to occur within the limits of the Transpanamanic Sub-region. After a short general introduction on the monkey-life of Central America and a review of the previous authorities on the subject, Mr. Alston takes the species individually and gives us an excellent account of each of them, including its history, habits, and distribution. Out of the ten known genera of American monkeys, six are represented by one or more species in Central America, and one of these (*Ateles vellerosus*) ranges as far north as the upper basin of the Tampico River, in the State of San Luis Potosi, about 23° N. L. This is the highest point north at which Quadrumana are known to occur in the New World; but in the Old World they certainly extend further north, as, besides the Rock of Gibraltar, a well-known locality of the Barbary Ape—the Japanese Island of Niphon is inhabited by a peculiar species of Macaque which probably extends northwards of the 35th parallel.

In working up his next order, the Chiroptera, Mr. Alston has largely availed himself of the labours of Dr. Peters and Mr. Dobson, both well-known authorities on this difficult group, of which the Central American species are numerous, and of great interest. We are presented with an excellent figure of *Chiroderma salvini*, a discovery of Mr. Salvin's in Costa Rica, recently described by Mr. Dobson. The Insectivora, which follow next in order, are but feebly represented in the Neotropical Region, where their place seems to be occupied by the small marsupials of the family Didelphyidæ. Four species of shrews of the genera *Sorex* and *Blarina* are the only true insectivora yet known to occur within the limits of the present work.

The "Aves" of the present work are undertaken by the two editors themselves, and are worked out in a somewhat more elaborate manner than are the mammals. Latin diagnoses of all the species are given, and besides the ordinary particulars as to their history and affinities many details as to their habits in their native wilds are extracted from well-stored note-books of the authors. The plates accompanying this division of the work, by Mr. Keulemans, are well executed and well-coloured.

The "Rhopalocera," also prepared by the editor, though in this case Mr. Godman's name is placed first, as taking, we suppose, the greater share of the labour in this section upon himself, are likewise fully treated of and illustrated by some very beautiful plates. There is not, however, so much scope in this group for the records of personal observation as in the case of the birds.

Besides the Mammals, Birds, and Butterflies we have in part ii. of the "Zoology" the beginning of Mr. Bates's essay upon the Longicorn Coleoptera of Central America. Of this it need only be said that neither Mr. Bates's ability to treat of any portion of one of his favourite groups of insects, nor the mode in which he has executed his present task are likely to be questioned. The thorough character of all Mr. Bates's work is well known, and in this case its value is increased by the beautiful coloured plates by which some of the greater rarities are illustrated. Our editors may well be congratulated on having pressed such a first-class recruit into their service.

Besides the two zoological parts above mentioned the botanical parts of the "Biologia Centrali-Americana" by Mr. Hemsley have also been issued. These contain an enumeration of the Phanerogamous Plants of Central America as far as the Meliaceæ, according to Bentham and Hooker's arrangement, with the localities added, and the characters in the case of the novelties recently described. Six or seven plates by Fitch are attached to each part, some of which are coloured from original sketches made by Mrs. Salvin in Guatemala. What the exact extent of the botanical portion will be we do not find stated, but we presume that it will when complete embrace a list of all the known Phanerogams of Central

America, and we believe the Filices are also to be included.

We are pleased to see that at the conclusion of the work it is announced that an introductory volume will be given containing an account of the physical features of the country and a series of maps. No specially faunistic work should be issued in these days without a map, and in that map moreover all the localities mentioned in the letterpress should be inserted. Furthermore care should be taken that the names of the places should be spelt alike in the letterpress and in the map—a point which in several instances that have come before us, has not been sufficiently attended to.

We are, however, fully aware that in the present case our authors are well acquainted with the value of geography —one of the two "*faces Zoologiæ*," as the late Prince Bonaparte called it, and we do not fear that they will even spell their names of places incorrectly. And on the whole it may be fairly said that the "Biologia Centrali-Americana," if carried, and we doubt not it will be carried, to its promised extent, favoured as it is by the co-operation of some of the most accomplished naturalists of the day, will not only remain a lasting testimony to the learning and munificence of its editors, but will also equal in completeness and finish any geographical work on natural history ever published.

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. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.*]

Visualised Numerals

IT may interest those who have read my memoir in NATURE, vol. xxi. p. 252, on visualised numerals, to learn some of the principal results obtained thus far through its publication. I have received several new diagrams more or less similar to those already published, so that I have now about thirty of them in all. My new contributors are of the same classes as before. There is only one high mathematician among them; the remainder are pursuers of science, authors of various degrees of reputation, persons engaged in tuition, students at Oxford and Cambridge, some other adults, and one schoolboy. If my collection becomes still further increased, I have grounds for belief that I shall be able to classify the cases, and to extract more meaning out of them than has hitherto been feasible.

It has been a satisfaction to me to receive emphatic acknowledgment of its correctness from the author of the curious shaded diagram (Fig. 5) in the memoir. The sketch sent to me was drawn with evident painstaking, but it was rubbed and faint; the engraver, however, succeeded in justly interpreting it, and supplying its defects of tone. Fig. 4 is unfortunate, and I am to blame. I stated in the accompanying text that I had compiled it from a large diagram, much as a map-maker would compile a small map from an elaborate itinerary. However, my map proves to be a failure, so I withdraw it. The other diagrams were almost exact reductions of plain drawings; their truth has been acknowledged in one group of cases, and I have no grounds for doubt as to the remainder. FRANCIS GALTON

42, Rutland Gate, London

A Psychological Aspect of the Vortex-Atom Theory

IT is a very generally accepted fact that the phenomena of thought are at least *connected* with a physical basis, however difficult it may be at present to trace the connection. The dependence, however, of mental attributes and sensations upon brain-structure, is too notorious a fact to admit of doubt by competent judges. This view is illustrated well by a remark of Prof. Huxley's in his essay "On the Physical Basis of Life," viz.: "And if so, it must be true in the same sense and to the same extent that the thoughts to which I am now giving utterance and your thoughts regarding them are the expression of molecular changes in that matter of life which is the source of our other vital phenomena" (*Fortnightly Review*, 1868).

It becomes evident in view of this that the phenomena of thought would be enormously influenced by the changes or permutations of which the molecules of matter were capable. Under the old theory of *perfectly rigid* molecules, it would seem difficult to conceive permutations enough to act as an accompanying physical basis to the phenomena of thought, for according to this theory, the mere motion or change of place of the molecules among each other would be the sole permutations of which they could be capable. But the modern theory of vortex-molecules shows molecules to be *elastic* bodies, which are consequently "capable of *infinite* changes of form"[1]—as the late Prof. Clerk Maxwell remarks [*Encyc. Brit.* 1875, Article "Atom"]. It would therefore follow that according to the modern theory, the permutations of the physical accompaniment of thought would be absolutely *infinite*, in analogy with the infinite variety and range of thought itself. Possibly this may be a point of interest, if indeed it has not already been reflected on by others.

London S. TOLVER PRESTON

A Speculation Regarding the Senses

ON examining the modes of action of the senses we find a series of advances in refinement. Beginning with *touch*, we find it has primarily to do with *solids* which come into *direct* contact with the organ. In *taste* a *liquid* medium is necessary. In *smell* we have minute particles carried by a *gas*. In *hearing* we have *vibrations* (longitudinal) in a gas. In *sight*, finally, we find transverse vibrations transmitted by a finer medium, the *ether*.

Now, whatever views may be taken of the doctrine of evolution, there can be no doubt of the progress of the human race in what we may generally here term *power*. And it is interesting to look into the future and inquire whether future developments of the relations between the *ego* and the *non-ego* may not, in time, take such forms as will be equivalent to the acquisition of new senses.

Guided by the gradation above referred to, I would throw out the suggestion that the molecular vibrations in the brain accompanying thought, may affect a surrounding medium, and through that, other brains at a distance, awaking in these corresponding vibrations and thoughts. The medium might be supposed, perhaps, one of different nature from that in which light-vibrations occur, or (not to multiply ethers) the same as the so-called luminiferous ether; and in the latter case we might suppose the vibrations such as not to be appreciated through any of the present senses of ordinary persons.

A person of high refinement and delicate organisation has a wonderfully exalted power (as compared, say, with a country bumpkin) of interpreting the *tout ensemble* of external appearance and bodily motions of another person in his presence, thereby perceiving at a glance much of the thought of that other, as it arises. But the kind of action I have referred to is of a still more delicate kind, and may be supposed to obtain when the eyes, and perhaps other avenues of sense, are closed. It might be termed a kind of *induction of thought*.

This speculation is not, I think, without some encouragement in actual fact. It is a familiar experience that two persons who are together will discover themselves to have been thinking of the same thing at the same moment; and this without any apparent cause in what one *sees* in the other, or in association of ideas in conversation. The ascertained facts of *clairvoyance* and *mesmerism*, however, are what I have more specially in view, and the light in which I would place them is that of a natural development of human faculty, at present appearing only sporadically and in few persons, but destined, perhaps,

[1] The molecules of matter, according to this theory, though indestructible (like the molecules of the ancients), are nevertheless *elastic*, or capable of distortion or changes of form (much in analogy with larger scale elastic solids), the molecule always tending to recover its natural symmetrical shape when released from constraint. These changes of form may of course be conceived infinite in variety, without the total amount of distortion itself being at any time great. This *elasticity* possessed by molecules is sufficiently proved by the vibrations of varied periods which the spectroscope shows them to be capable of executing.

by-and-by to become a universal possession in more or less degree.

It may require some peculiar state of mental calm or abstraction for this reading of the thoughts of another (apart from external expressions appreciated by the other senses) to become practicable, just as, in order to perceive distinctly the over-tones of a musical sound, it may be necessary to quench the fundamental tone.

As to the modification in the human body, supposing the sense in question to become general, this might be of a very minute character, constituting, not in the ordinary view, yet in a quite correct one, a distinct *organ*.

With regard to the influence of distance on the supposed sense, little, of course, can be said; but it is perhaps noteworthy that corresponding to the gradation referred to at the outset there is a general gradation in the distance at which the sense-exciting cause is capable of operating; from the direct contact of touch, to the action of light at the distance of a remote fixed star.

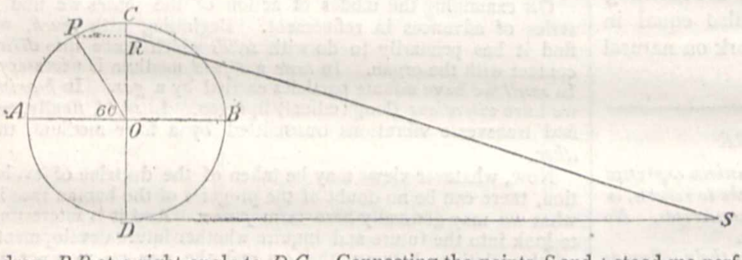
M.

The Circumference of the Circle

To some readers of NATURE the following construction will erhaps be of interest:—

Take $A\,O\,B$, $D\,C$ two diameters of a circle at right angles to one another.

Make the length of the tangent $D\,S$ equal to three diameters of the circle $A\,D\,B\,C$, then make the angle $A\,O\,P = 60°$, and



draw $P\,R$ at a right angle to $D\,C$. Connecting the points S and R you will find the length $R\,S$ very nearly equal to the circumference of the circle.

This will be clear from the following proof:—

From the triangle $D\,R\,S$ we have—

$$RS = \sqrt{DR^2 + DS^2}.$$

But taking the diameter $DC = 1$ the length DS is $= 3$, whereas $DR = OD + OP \cos 30° = \frac{1}{2} + \frac{1}{2} \cos 30 = 0{\cdot}9330127$.

Therefore—

$$DR^2 = 0{\cdot}9330127^2 = 0{\cdot}8705127 \text{ and}$$
$$DS^2 = \quad 3^2 \quad = 9{\cdot}0000000$$

$$DR^2 + \quad DS^2 \quad = 9{\cdot}8705127$$
$$RS = \sqrt{DR^2 + DS^2} = 3{\cdot}141738,$$ whereas the exact value of π is $3{\cdot}141592$,

giving a difference of $0{\cdot}000146$, or $0{\cdot}0046$ per cent.

This approximation is, of course, more than sufficient for practical purposes. Although this method has been found by me quite independently, yet I shall not be surprised to hear of its having been proposed before by others, for it is almost too simple not to have occurred to somebody else as well as to me.

Prague, Spálená ulice, 2 nové, January 11 L. HAJNIŠ

Sun-Spots, &c.

I READ with interest the letter of Mr. Bedford's in NATURE, vol. xxi. p. 276, on "Sun-Spots." Perhaps the following may interest Mr. Bedford, and as I have not seen this noticed before by students of the solar orb, it may interest others besides Mr. Bedford.

Prof. Sayce, in his Lectures, says: "The Accadians had anticipated our almanack-makers in discovering a connection between the weather and the changes of the moon; indeed all kinds of astronomical phenomena were supposed to have an influence upon the clouds; and in anticipation, as it were, of Dr. Hunter, the same weather was expected to recur after a cycle of twelve solar years." . . . Even the appearance of the sun was not allowed to go unnoticed, and in one place we are told that on the 1st of Nisan it was "bright yellow," and in another that it was "spotted." Who, says the professor, "would have thought of looking for a notice of sun-spots in the clay tablets of ancient Babylonia?" Lectures, pp. 53-54. See also the "Astronomy and Astrology of the Babylonians," by the same, in the *Transactions* of the Society of Biblical Archæology, vol. iii. pp. 145, 339.

EDWARD PARFITT

Devon and Exeter Institution, Exeter, January 27

Intellect in Brutes

IT might prove interesting to some of your readers to put the following incidents on record relative to intellect in brutes:—Some time ago I kept in town a bitch and three of its puppies; the former had a strong pair of lungs and a weakness for letting the passers-by know it; when the latter became of age they exhibited all the hereditary peculiarities of the mother, and when the four animals joined in chorus, which was their favourite amusement at night, the result was anything but agreeable. Some of my friends hinted to me that if that state of things continued I should probably be indicted for causing a nuisance, and I therefore determined to explain to my four animals that they really mustn't bark. One night I remained late in town, and having provided myself with a stick, I waited till I heard one of them bark, and I immediately afterwards went out and chastised him, or rather the one I thought had made the noise. I was, however, soon met by a difficulty; although I could recognise the bark of the old one, I could not discriminate well between those of the puppies; and whilst the old one was silenced after a few chastisements, the puppies were not; probably in mistake I had thrashed the wrong puppy. I therefore hit upon the plan of making the whole four responsible for each other, and as soon as I heard any one of them bark I applied my stick freely to the whole four, the one after the other. When this had been done two or three times I heard one of the puppies bark, and the next moment it gave a pitiful squeal; the mother had it by the neck. I went out and patted her, thus explaining that she had done well. She wagged her tail, as much as to say she understood me perfectly, and the dogs never barked again except upon the most provoking occasions.

Some other instances which I observed lately might be mentioned as tending to show that animals of a much lower class exhibit reasoning faculties. I had occasion lately to keep some leeches and water-beetles; they were put into round open glass vessels, about six inches high and about two-thirds full of water. A medical leech which was put into one of these vessels got out, and within an hour afterwards it was found on the table and replaced in the water. Now although the vessel was left uncovered as before, this leech never again tried to get out. A horse-leech and two water-beetles, treated in the same way did the same thing once, and once only; each preferred the water to the dry table, and on being replaced they never tried to get out again; *ergo*, they had been taught by experience. Is this not a high order of intelligence? How many examples have we of the genus *homo* where so much intelligence is not exhibited?

Manchester, January 17 W. THOMSON

SEEING a letter in NATURE, vol. xxi. p. 276, with the heading of a "clever spider," puts me in mind of a circumstance that came under my own observation near Tremadoc, in North Wales, many years ago. I sat down on a bank about four o'clock in the afternoon after a long day, when I presently saw I was close to one of the common garden spiders of rather large size, with its pretty spreading net-like web about a yard from the ground; so, for want of something to do, I alarmed the spider to discover where his *den* was, when off he trotted about the distance of a foot to a couple of leaves nicely tied together, where he stayed perhaps ten minutes; I then saw a beetle of rather large size walking at my feet—one of those slow moving dull black ones—I am not coleopterist enough to know its name; I picked it up and put it in the web at a place I thought sufficiently strong to hold it, when out rushed the spider in his boldest manner. But when he saw who his visitor was, what an alteration in his manner! He drew back, and rapidly separated the cords, when down dropped the beetle on a single line, rather quickly, to within about 4 inches of the ground, so that he was suspended on a line about $2\frac{1}{2}$ feet long. The spider then trotted back to his den. The beetle was now struggling in its slow, awkward-looking fashion. I must have stayed and watched them for about twenty minutes, when out came the spider and descended the single line to the beetle, on which he boldly rushed; after a few seconds the beetle's struggles got weaker and weaker, when the spider returned to its den; in a few seconds more the struggles of the beetle ceased. Now, did the spider intend the beetle for its food when he cut away his web to save it from destruction from the beetle's struggles, or was that an after-thought, or why should he know it was a "creature comfort"? and was the fact of the line being so near the ground an accident, or was it premeditated? If you put a small pebble or small piece of wood in a web, a spider will let it drop altogether; if you put a grasshopper in it he rapidly turns it round till the creature looks like a mummy; but I suppose circumstances alter cases even with spiders.

JAMES R. GREGORY

THE following fact may be of interest to those of your readers who are connected with the correspondence in your columns regarding the possession of intellect by brutes.

Having been much worried by the depredations of bandicoots (*Mus giganteus*) I laid three pieces of bread for them smeared with Roth and Ringeisen's phosphor paste. Next morning the pieces of bread were found near the door where they had been placed but turned *upside down*. The bandicoot evidently was suspicious of the poison, had turned over the bread and nibbled away all the sound portion. On the next night I smeared the poison on very thin slices of bread, leaving hardly any of it free from the paste. On this occasion the caution of the bandicoot seems to have deserted it, for the bread was eaten, and the dead animal was found next day in the garden.

Bangalore, India, January 8 ELPHINSTONE BEGBIE

Suicide of the Scorpion

Apropos of the discussion on this point that has lately taken place in NATURE, will you allow me to say that I tried the experiment referred to therein a score of times at least during my long residence in India, and that I never saw the phenomenon so graphically delineated by Byron. My experiments were conducted in cholera and other camps, in the open air, often in the presence of others, and always under circumstances which could admit of no doubt. The conclusion I came to in the matter was that "the scorpion girt by fire" is too stupid or too cowardly a creature to "cure its pain by darting its sting," or anything else, "into its desperate brain." It either rushed blindly into the flames at once, and was then and there destroyed, or it wandered meaninglessly about the margin of "the circle," recoiling nervously from the actual contact, or retiring as far as it could from the heat, to resume, after a short respite, its old manœuvres. I believe as the result of these inquiries that the impression or belief created by the fine imagery of the great poet is a myth and nothing more. WM. CURRAN

Warrington

WILL Mr. Gillman or some other tell us *how* scorpions achieve suicide? The animal stings, as I know to my cost, by a backward lash out and straightening of the tail, and the force which drives the somewhat blunt point into the enemy goes on accumulating as the reversal becomes more complete, and reaches its maximum on or near the horizontal plane and at the furthest point of extension. But when the tail is drawn back above the animal's head, the point is turned upwards, and therefore away from the head, and even if it could be turned towards the head, there is no possible force to drive it through the tough or hard carapace.

Can a man pummel his own back? Can a horse kick its own belly? But the feat attributed to the scorpion, apart from its moral obliquity, is physically even more triumphant. B.

Stags' Horns

OBSERVING in a late number of NATURE a communication concerning the disappearance of stags' horns after being cast off, and a request for information upon the subject from whatever source it might be had, I venture to send the following:—

A few winters ago I spent some weeks in the woods of Georgia, where most of my time was devoted to deer-hunting. In roaming over the woody *hummocks* of that country I several times stumbled upon the cast-off antlers of bucks. Being, like your correspondent, impressed with the popular belief that these were always buried or in some way destroyed by the animals, I inquired of old hunters if it was of common occurrence to meet with them, and was told that they were not rarely found just as we had seen them upon the occasion in question. I suppose that the popular belief in their burial or destruction arose out of the fact that about the time for shedding their horns the bucks retire to the most secluded spots accessible so as to avoid disturbance by other bucks or any enemy during the first few days of the tender, velvety stage of the new horns, and into such retired places man does not commonly venture.

This brings to mind the similar habit which prevails among most crustaceans. The edible crab of this region, for example, waits for a very high tide, and goes with it far inland, where, in shelter of some dark nook, and quite away from its common enemies, it slips off the old shell and spends a few hours on land awaiting the hardening process of the new one before entering again into the struggles of life. The fishermen have learned, however, that the most favourable times for catching *soft crabs* is connected with certain phases of the moon, to which they attribute some mysterious influence upon the crabs directly; of course the dependence of tides and moon solves this little mystery.

BOLLING W. BARTON

Baltimore, Maryland, U.S.A., January 22

MOUNTAIN BUILDING[1]

FEW problems in physical geology are more fascinating than that which deals with the origin of mountains. At the same time few present greater difficulties. In the first place it is absolutely necessary to ascertain the facts of mountain structure before proceeding to frame any theory to account for them. Yet to do this involves an amount of mere physical toil which of itself raises a formidable impediment to progress. For the mountains cannot be understood from a distance. One may not intuitively interpret them by merely looking at them from below. They must be climbed and scrutinised in detail from crest to crest and valley to valley. But to be able to understand what one sees in these elevated regions, one must have an eye that has been well trained in the observation of geological structure, and which, while losing sight of no essential detail, can yet detect the dominant lines amid the apparent disarray of crag and scar, slope and pinnacle. In the next place, having elicited the fundamental facts, it is needful to find for them some explanation which, while connecting them harmoniously and luminously, shall be in strict accordance with the laws of physics, and from the point of view of geological dynamics may be regarded as not only possible but probable.

Thus two obvious paths lead to the consideration of the subject. By the one we are conducted into the region of geological observation in the field. By the other we are drawn to the laboratory and the workshop, where the processes of nature can in some measure be repeated and watched. But these two roadways lie near each other, and the traveller along either of them, if he would keep himself from profitless divergence, should never lose sight of the other. Unfortunately this caution has not always been followed. Hence theories of mountain growth have been proposed, some of them wholly regardless of the real facts of mountain structure, others as defiant of physical possibilities.

Within the last few years the most detailed studies of the actual structure of mountains yet attempted have been carried out among the Alps. Chief among these are the admirable monograph of Dr. Baltzer upon the Glärnisch, and the still more remarkable and beautifully illustrated work of Prof. Heim, on the mechanism of mountain-making. These two writers deserve the thanks of all who take interest in the many questions which the forms of the mountains never cease to raise in the mind. They

[1] "Der Mechanismus der Gebirgsbildung." Dr. F. Pfaff. (Heidelberg, 1879.)

have done much to supply what has all along been a fundamental defect in the conditions for the discussion of the problem—the want of detailed and carefully observed facts. But geologists will never be able satisfactorily to work out the problem until they construct large detailed sections on a true scale, vertical and horizontal, and insert upon them the thicknesses and angles of inclination of the rocks in their exact relations. It would be a task well worthy of the time and energy which any enthusiastic student of the science could bestow to run such a section across the Alps, or at least across some typical portion of the chain. The true outlines and related structure as thus determined, would make most of the existing diagrams of alpine structure appear as ludicrous exaggerations.

Among those who have essayed to follow in the wake of Sir James Hall, the founder of experimental geology, and to seek a solution of some of the problems of mountain building by well-devised experiments, Daubrée and Favre have in recent years been specially successful. Another experimenter has just appeared in the person of the accomplished Dr. Pfaff, of Erlangen. His previous works have shown him to possess no ordinary powers of scientific exposition, and in particular his "Allgemeine Geologie als exacte Wissenschaft" deserves the attention of geologists as a remarkably incisive criticism of their science in its present aspects. He is essentially an experimenter, who would reduce every geological problem if possible to the test of actual measurement and experiment. Some of his own practical work in this department is full of ingenuity and suggestiveness. He has now come forward as a disputant in the vexed question of the formation of mountains. His critical faculty, however, here shows itself rather destructive than constructive. He institutes numerous experiments to prove the inadequacy of previous theories, but he leaves us with very little that is satisfactory to put in their place.

As we read Dr. Pfaff's essay and note how he gravely argues as to the capabilities of rocks under pressure and the processes of mountain building, from what he has been able to do with a few square inches of limestone, a steel punch, and other appliances, we are reminded of the censure pronounced by Hutton on the temerity of those who "judge of the great operations of the mineral kingdom from having kindled a fire and looked into the bottom of a little crucible." He forgets that while much may be learnt from experiment, it must always be first of all determined how far the conditions of experiment resemble those of nature. Thus he takes a solid cylinder of Solenhofen limestone 4 mm. in diameter, tightly fitting into a hollow steel cylinder with a small aperture on one side, and subjects it to a pressure of 9,970 atmospheres for seven weeks. He then finds that the stone has not in the least degree been forced into the empty aperture prepared for it, and that its microscopic structure shows no sign of internal alteration or rearrangement. Accordingly he concludes that even with so high a pressure rock acquires no plasticity. With this conclusion no fault can be found until it is applied to the solution of problems in mountain structure. Surely Dr. Pfaff does not mean to affirm that there is any analogy between his solid cone of homogeneous limestone tightly fitting into a steel cylinder and the alternations of various sediments differing so much in texture, structure, density, and inclosed water which constitute most of the visible part of the earth's crust. He does not seem to be aware of the fact that rocks have been experimentally proved to be plastic under much less pressure than he applied. We would recommend him to read the classical memoir of Sir James Hall and the researches of Daubrée and Tresca on the flow of solids. He will find also some convincing proofs in Mr. Miall's paper on the contortion of rocks, that even on the surface, under every-day conditions, not inconsiderable curvatures of solid stone take place merely through gravitation. If he will visit this country we shall be happy to conduct him to some graveyards where the centres of vertically-placed slabs of Italian marble have, under the influence of weathering, been started out from their backing, so that they "belly" out like partially-filled sails.

Dr. Pfaff does not, of course, deny that rocks have been violently compressed and contorted, and he is no doubt well aware that their inclosed fossils have often undergone extraordinary deformation. He contends, however, that these are mere superficial phenomena, and endeavours to support and explain his contention by sections of the earth's crust, about which we venture to predict that Prof. Heim and his Swiss colleagues will have something to say before long. Dr. Pfaff has a theory of his own to explain curvature and deformation. He regards these as the results of the co-operation of water with gravity! Though hitherto no Neptunist, he now distinctly avows himself as a believer in the paramount power of water in the elevation of mountains. It is a pity that after more than a hundred pages devoted to the demolition of all our views as to the effects of terrestrial contraction due to secular cooling, he should tantalise us with a mere brief statement of his own theory. Perhaps it seems so self-evident to himself, that it needs no elaborate experiments to prove its truth, and no expanded statement to insure its acceptance. That a man at this time of day can honestly persuade himself that the upheaval of mountains, the plication, inversion, and deformation of rocks can be accounted for merely by the effects of subsidence due to the abstraction of materials from below by percolating water seems incredible. But that such a creed should be professed by one who has shown himself so good an observer and so acute a reasoner, is still more astonishing. When, after perusing the greater part of his book, and noting argument after argument, and experiment after experiment brought forward to upset all accepted theories on the subject, one comes suddenly and without warning upon his own theory, it is as if some rogue had incontinently put the lamp out. One does not know what to make of the situation. There is something too ludicrous about it. Serious argument is no longer possible. Dr. Pfaff must be bantered out of his hydropathic geology. His abilities are too great to be lost in a monomania of this kind. We would recommend for his speedy restoration to geological sanity a trip into Switzerland, under the care of Drs. Baltzer and Heim. This treatment, if taken in time, will, no doubt, restore him at least to such measure of health as can be enjoyed by a man who works out his geology in his study and laboratory rather than in the field.

A. G.

THE SWEDISH NORTH-EAST PASSAGE EXPEDITION

THE following notes are taken from a letter from Prof. Nordenskjöld to Mr. Oscar Dickson, dated Ceylon, December 16, 1879, printed in the *Göteborgs Handels Tidning*:—

Dredging was carried on at a number of places on the coast of Japan, but with scanty results, in consequence of the poverty of the sea-bottom in animal life. The same was the case with the dredgings which were carried on between Hongkong, Labuan, and Singapore, and in the Strait of Malacca, although the bottom consisted in some places of clay, in others of sand, coral-sand, or rock, and thus ought, at least at some of the places, to be favourable to the development of a rich animal life. While the trawl-net in the Polar Sea almost always brought up several hundred animals, the zoologist in these southern seas obtained seldom more than one or two at each draw, and frequently not one. By far the most abundant animal life has been found during the Swedish Arctic expeditions, at favourable places in the bottom of the Polar Sea; for example, at a depth of between 20 and 100 fathoms in the middle of Hinloopen Strait in Spitzbergen, on the east coast of Novaya Zemlya, in the sea east of Cape Chelyuskin, and south of Behring's Straits. At these places the temperature of the sea all the year round is between 0° and −2°·7 C. A temperature at or under the freezing point appears thus to be much more favourable for the development of an abundant animal life at the sea-bottom than one of 15° to 25° C., a very remarkable circumstance, which, as far as Nordenskjöld knows, has not received the attention which it deserves. It is to be remarked, however, that the invertebrate animals in the south are larger and finer than in the north, and that the shore fauna, which is entirely absent in the sea of the high north on account of the destructive action of the drift-ice, is here richly developed.

Japan is so poor in land- and fresh-water crustacea, that one often searches for hours in the most favourably situated places without finding a single specimen. Even in the most northerly part of Scandinavia more land crustacea may in many places be collected in a few hours than in Japan in as many days. Lieut. Nordquist, however, has made a fine collection, which is expected to yield many interesting new contributions to the fauna of Japan.

In the numerous dredgings carried on during the voyage from Japan to Ceylon at depths in which algæ are met with in abundance on the coasts of Scandinavia, *not a single alga was brought up by the dredging apparatus.* Even in the shore belt marine plants are in many places almost wholly wanting. Some places were found, however, more fortunately situated. The observations made here and the information obtained by an examination of the collections in the museums of Tokio have enabled Dr. Kjellman to obtain a general view of the occurrence of algæ on the east coast of Japan of special interest in many respects in connection with researches carried on by him during the preceding part of the voyage, for example, with respect to the boundaries of the areas occupied by different algæ, with respect to the mutual relation between the abundance of individuals and species at different places, and with respect to the types which are to be considered distinctive of the different areas.

The lichen flora of Japan was examined by Dr. Almquist. In the more elevated regions, as on the sides of the mountain Fusijama, 13,000 feet high below the snow limit, at a height of 6,000 to 8,000 feet above the sea, it has a certain resemblance to that of Scandinavia, but in the low country it is limited to a very few localities. In the purely tropical countries, for instance at Labuan and Singapore, the lichens appear to be confined almost exclusively to the bark of trees, and the whole of this division of the vegetable kingdom here consists mainly of a single group, *Sclerolichenes*, which occur in abundance and in very varying types.

Prof. Nordenskjöld and Lieut. Hovgaard ascended the mountain Asamajama, a still active volcano, 8,200 feet high, on October 4.

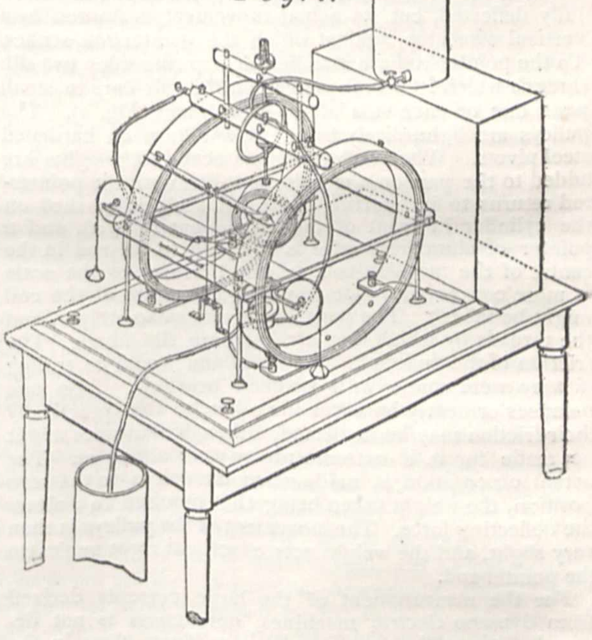
Prof. Nordenskjöld has made extensive collections of fossil plants from fossiliferous strata at Mogi, a fishing village on the coast of Japan, and from the coal-mine Takasima, both in the neighbourhood of Nagasaki, and from the coal-seams at Labuan. The fossils from Mogi lie in a fine white clay slate, and consist almost exclusively of beautiful leaf impressions. At Takasima the fossils consist principally of water plants imbedded in the brownish-black shale which accompanies the coal. At Labuan the fossils lie imbedded in balls of clay-ironstone found in the sandy beds between the coal-seams. They consist of ferns, *Cycadeæ*, and large-bladed leaf-trees, which appear to have a tropic stamp, while the Mogi fossils, on the other hand, indicate a moderately warm climate.

AN ELECTRO-DYNAMOMETER FOR MEASURING LARGE CURRENTS[1]

THE use of electric machines of large size for the generation of currents of great strength has become extensive, and promises to increase materially. In connection with this, the best mode of measuring the currents obtained is a matter of much importance as well as one of some difficulty.

Of the possible methods the galvanometric is probably the most used, but it is objectionable as shunts of low resistance must be employed. In general, a method depending upon the estimation of a *very small proportional part* of the magnitude to be measured is objectionable, since extreme accuracy is necessary and errors of observation are magnified. The mode of measurement by the electro-dynamometer is to be preferred for many reasons, and it has also the advantage of being applicable to to-and-fro currents, as well as to those in one direction. Weber's electrodynamometer is only suitable for measuring very small currents unless shunts are used. Trowbridge has designed an electro-dynamometer through which large currents may be transmitted and directly measured (*Proc.* Am. Acad. Arts and Sci., October 9, 1878). This instrument works well and gives good results.

Fig. 1.



During the past year the writer has been experimenting at the U.S. Torpedo Station with an electro-dynamometer differing from Trowbridge's in the manner of determining the deflective power of the current, and which seems to present some advantages in simplicity and readiness of working, while especially suitable for technical use. In its general plan, particularly in the arrangement by which the entire current may be passed through the instrument, it follows Trowbridge's form.

Fig. 1 is a general view of the instrument. Figs. 2 and 3 show the details of the suspended coil. The large, fixed coils are made of thick copper ribbon. The turns are insulated from each other, and the metal framework is insulated from the coils. The suspension arrangement

[1] By Walter N. Hill, Chemist to the U.S. Torpedo Station, Newport, R.I., U.S.A.

is placed on the top of the fixed coils and insulated from them.

The deflecting coil is made of thick copper ribbon fastened with insulated rivets. In its centre, and parallel with it, is a light brass rod or pointer. A copper rod in connection with the outer end of the coil has an iron or nickel-plated point, which dips in mercury contained in a double-walled metal cup, B, on the base-board. A similar rod from the inner extremity of the coil ends in an iron or nickel-plated cup, C, containing mercury. The coil hangs under the metal cylinder, D, so that a plunger, A, in the latter can dip in the mercury in the cup C of the former. The suspension is of fine sewing silk, waxed or treated with shellac. The thread passes over a little pulley, E, above, with both parts parallel, or nearly so, and close together. As represented in Fig. 1, the large coils are connected in series. The current, after traversing the left-hand coil, is led by a wire to the cylinder, D, thence by the plunger, A, to the cup, C, through the small coil to the cup, B, which is connected by a wire with the right-hand coil. In order to prevent heating of the mercury connections, a stream of cold water is passed through the hollow plunger, A, and between the walls of B, from a jar above, connected by rubber tubes.

When the current passes, the suspended coil is powerfully deflected, but its actual movement is limited by a vertical wire stop, against which the pointer-rod strikes. To the pointer-rod are attached, on opposite sides, two silk threads which lead over pulleys on the side-bars to small pans, one on each side of the instrument (Fig. 1). The pulleys are light, nicely balanced, and turn on hardened steel pivots. When deflection has occurred, weights are added to the pan on the side opposite until the pointer-rod returns to its starting-point. A scale is marked on the cylinder in front of the instrument (Fig. 1), and a pointer of aluminium wire is fastened to the rod in the centre of the movable coil, so that it traverses the scale (a more convenient mode of noting the return of the coil might be taken). The pans are of the same weight, and the threads by which they are hung are silk fibres. The friction of the pulleys is very small and would be trifling if they were made with jewelled bearings. Also one balances or nearly balances the other, so that practically their friction may be neglected, although allowance might be made for it, if extreme nicety were aimed at. The actual observation is made when the coil is in the zero position, the weight taken being that required to *balance* the deflecting force. The movement of the pulleys is then very slight, and the weight acts exactly at right angles to the pointer-rod.

For the measurement of the large currents derived from dynamo-electric machines, minuteness is not demanded, since the variations due to fluctuations in the currents, alterations in resistance, &c., are much greater than the limits of observation in such an instrument as this. Quickness and simplicity of working, together with strength and compactness, are required in the electro-dynamometer, and this instrument possesses these practical advantages, while it is capable of a good degree of accuracy.

The instrument shown in the figures was made for experimental trial, and is defective in certain details; still it was found to be a good working piece of apparatus.

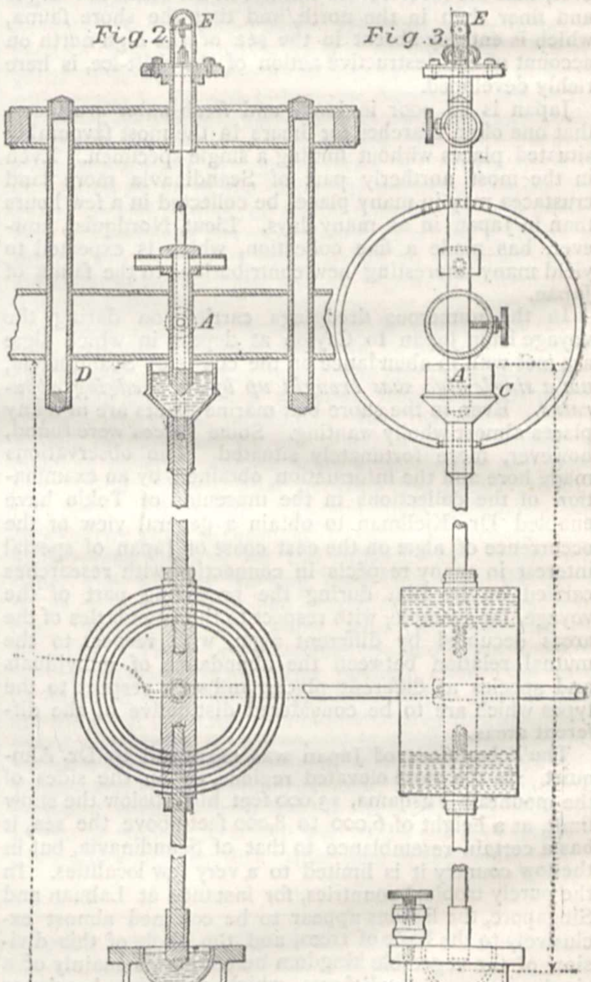
Theory of the Instrument.—The expression for the strength of current is very simple. The weight found is that required to balance the deflective force and is observed at zero, so that the earth's and local attractions are avoided, nor does the torsion of the suspension enter. Let

S = strength of current in webers.
w = weight used in milligrammes.
l = length of weight-arm, or distance from point where weight acts, to centre of system.
G = constant of large coils.
g = constant of small coil.
C = constant of instrument or length of magnetic arm.

By the theory of the electro-dynamometer, the force acting to deflect is represented by the expression $\frac{2\pi n}{r} \times g \times S^2$, in which $\frac{2\pi n}{r}$ is the constant of the large coils or G, and g the constant of deflecting coil. This force acts with the arm C and is balanced by the weight acting with the arm l. Hence

$$S^2 = \frac{lw}{CGg}.$$

The coils being large, G and g are readily ascertained



from measurement, and l is a known distance. With the instrument in question, C was found by passing the same currents through it and through Trowbridge's dynamometer, the constant of which was accurately known.

C, l, G, and g being known, it is evident that from the observed w, S may be obtained with little calculation. Or, a table may be drawn up from which the value desired can be derived by inspection. Also, a set of weights can be prepared which will represent the current in webers directly. Doubtless this will often be convenient.

The instrument described has been worked with currents as small as 10 webers, but it is not quite sensitive enough for such use. With those of 20 webers and upwards it operates satisfactorily. Greater nicety of construction would confer greater sensitiveness, and it is probable that this method of observation can be advantageously applied in the construction of instruments for measuring moderate currents. It is, however, evident that this form of the electro-dynamometer is particularly suitable for *large* currents. We have

$$S : S' :: \sqrt{w} : \sqrt{w'}.$$

That is, as the current increases, the corresponding weights increase more rapidly and greater accuracy and minuteness are attained.

Thus, as the instrument I have experimented with has been arranged, a current of

20 webers	requires a weight of	530 mg.	
21 „	„ „	580 „	diff. 50 mg.
49 „	„ „	3,165 „	
50 „	„ „	3,295 „	diff. 130 mg.
80 „	„ „	8,230 „	
81 „	„ „	8,440 „	diff. 210 mg.

while a difference of 10 mg. is sharply indicated.

My best thanks are due to Prof. John Trowbridge, of Harvard, for advice and the use of his apparatus.

NOTES

THE Committee appointed by the French Minister of Public Instruction has awarded the *Prix de Volta*—50,000 francs—to Graham Bell

A TRANSLATION of "The Skies and Weather Forecasts" of Aratus, by Mr. E. Poste, M.A., of Oriel College, Oxford, will shortly be published by Messrs. Macmillan and Co. These poems, apart from a certain charm in the treatment of the subject, are not without interest as belonging to the literature of infant astronomy and infant meteorology. The meteorology of Aratus is of course merely a specimen of the popular weather wisdom of his day. But the faith it shows in the possibility of a science, and the sense of the importance of such a science, gives him a certain claim to the attention of modern scientific men. The notes to Mr. Poste's translation will be addressed merely to novices in astronomical knowledge.

THE *New York Times* announces the death at Waukegan, Ill., on January 6, of Mr. James W. Milner, at the age of thirty-nine. When barely arrived at man's estate he travelled through Minnesota and the adjoining States, engaged in making collections. At Waukegan Mr. Milner made some remarkable discoveries in the peat-beds, and the remains of an elk which he exhumed were exhibited for quite a number of years in the Chicago Academy of Sciences, until they were destroyed by fire. Such papers as Mr. Milner had written on these remains and on other topics of a a similar character, from their singular terseness and excellence, attracted the attention of the Smithsonian Institution. A correspondence, ensuing between the Smithsonian and Mr. Milner eventually led to his engagement by the present secretary, Prof. Spencer F. Baird, and, in 1871, Mr. Milner was appointed Deputy United States Fish Commissioner, with the particular duty of studying the habits, food, method of breeding, and catching of the white-fish. From these labours in what some six or seven years ago was quite unknown ground, resulted a work of the most thorough and exhaustive character, which may be cited as a model of patient and elaborate research. From the period of his entrance into the United States Fish Commission his labours were incessant. In the study and development of practical fish-culture, as understood in its widest sense, Prof. Milner may be said to have done more for it than any one else in the United States. His ingenuity and adaptiveness, combined with his thorough grounding in natural history, permitted him to solve many things in fish culture which before his time had been as problems. The wonderful successes he achieved soon made him a leading authority on these subjects, both at home and abroad.

THE death is announced, at the age of sixty-three years, of Mr. David Thomson, Professor of Natural Philosophy in the University of Aberdeen.

M. WALFERDIN, the inventor of the minimum thermometer, died at Paris at the end of January at the age of eighty-five, after a protracted illness of many years' duration. He was one of the members of the Constituent Assembly of 1848. Since that time he devoted all his leisure to scientific and artistic pursuits. He collected almost every picture drawn by Fragonard, one of the most celebrated French artists of the end of the eighteenth century. He sold his gallery to an English nobleman about twenty years ago, on condition that he should be appointed during his lifetime keeper of the gallery, with a salary of 500*l.* a year, and that the gallery should be exhibited at his own rooms. This precious collection will shortly come to England.

WE regret to state that General Morin, the well-known director of the Conservatoire des Arts et Métiers, is lying in a very precarious state in consequence of a severe cold. Great anxiety is felt for him at the Institute, of which he is one of the most respected and popular members. The General is aged eighty-five years.

ON Monday Prof. W. K. Parker, F.R.S., commences a series of nine lectures at the Royal College of Surgeons, on the Structure and Functions of the Vertebrate Skeleton, to be continued on Mondays, Wednesdays, and Fridays, to the 27th inst. Prof. Flower, in continuation of previous courses, begins his series of nine lectures on the Comparative Anatomy of Man, on March 1, to be continued as above to March 19.

WE are glad to learn that the College of Surgeons have seen their way to the purchase of the Barnard Davis Anthropological Collection, and that Prof. Flower is superintending the removal of the collection to the museum of the College.

THE death is announced of Sir Dominic Corrigan, the well-known Dublin physician, at the age of eighty years.

ON Tuesday afternoon the problem set by the accidental explosion of the 38-ton gun on board the *Thunderer* was solved by the explosion of the sister gun with a double loading. The gun was carefully loaded, and then a diagram was painted outside the gun showing the positions of the two charges and their projectiles. First was rammed home the Palliser cartridge of 110 lbs. of pebble powder, next the Palliser shell of 110 lbs., and the papier-maché wad. The second charge followed—namely, 85 lbs. of powder, a common shell, and another wad, and the double loading was complete. As marked on the outside of the gun, the 85 lbs. of powder lay just in the position where the gun swells in thickness to strengthen the powder chamber. After the firing the little dark cell was found strewn with fragments of the gun, the breech end only of which remained on the carriage, resembling with marvellous fidelity its unfortunate companion now exhibited in the Royal Gun Factories.

WE notice in the January number of the *Archives des Sciences Naturelles* an interesting letter by Col. Ward, on the meteorology of the high regions of Switzerland during December last. Whilst the valleys were covered with a thick fog, and the sun was visible only for very short intervals, bright sunshine glowed about Rossinières (a small town close by Chateau d'Oex, altitude about 3,240 feet); here the sun was seen daily for twenty-seven days, and twenty-one days were absolutely cloudless. On December 25 Col. Ward climbed Mont Cray, a mountain 6,793 feet high, situated between Rossinières and Châteaux d'Oex. The view from the top was never so clear and wide; it reached as far as seventy miles in each direction; the mountains of Lake Constance, the Bernese Oberland, Monte Rosa, Mont Blanc, the Vosges, and even the Black Forest, were quite distinguishable, as well as the plateau north of Mont Cray, with the towers of Friburg and Romont. On the contrary, a thick fog covered

Lakes Geneva, Neuchâtel, Morat, and Bienne, and the neighbouring valleys. The quite level surface of this fog is likened to that of a sea of milk which reached as high as 500 feet beneath the 4,900 feet high Col de Jaman. At Rossinières the planet Venus was seen with the naked eye in daylight from October 23 until the end of December.

ANOTHER interesting note, by Prof. Plantamour, inserted in the same number of the *Archives*, deals with the temperature of the St. Bernard. It happens every year that the temperature on the St. Bernard, during several hours, or even during several days, of December, is higher than at Geneva. But during December, 1879, this anomaly lasted for a far longer period of time than usual; the average temperature of December on the St. Bernard (2,070 metres above Geneva) was 8°·4 Celsius higher than at Geneva; out of the thirty-one days of the month only during fourteen days was it from 0°·04 to 6°·2 Celsius lower than at Geneva, whilst during seventeen days it exceeded this by 2° to 16°·4 (16°·4 on December 1, 13° on December 5, 7, and 31; 11° on the 8th, 13th, and 30th, and so on). Prof. Plantamour observes also how difficult it is in such cases to determine the mean temperature of the stratum of air between the two stations, and how great the error of the barometrical levelling and of the reduction of the observed pressure to the sea-level would be if we applied the barometrical formula to such cases when the usual distribution of heat is inverted as it was during December last. As to the temperature at Geneva, it was, during this month, 6°·9 Celsius lower than the average for fifty years; this difference exceeded four times the probable difference which, when deduced from fifty years' observations, is only ± 1°·72, the probability of such a difference being only 0·005.

THE results of a recent instructive experiment in sylviculture, extending over seventeen years, have been communicated to the French Academy by M. Gurnaud. His conclusions are as follows:—(1) That light when it strikes the ground, after being sifted in the foliage, stimulates the production of carbonic acid in the decompositions which produce humus, and also the decomposition of that gas by the green parts. (2) That the growth of tall trees is retarded, though their green parts expand freely in the atmosphere, under direct impression of the luminous rays, when the lower covert formed by trees of smaller size intercepts too completely the access of light to the ground, and diminishes its reflex action on the tops of the tall trees. (3) That the covert formed by underwood weakens this reflex action of light on the vegetation of tall trees rather by its composition, than in any other way; since, after a clearing which suppresses the oblique shoots, the vertical shoots retained do not offer any obstacle. (4) That humus, under too dense a covert, loses a part of its efficacy, and herein resembles farm-dung, which, too deeply buried, remains inert for several years. *En résumé*, it is demonstrated how the vegetation of tall trees may be improved by operating on the composition, consistence, and duration of the underwood.

A CORRESPONDENT of the *Times* writing from the Royal Mail Steamer *Para* at sea, January 17, records a volcanic eruption in the Island of Dominica, and also disastrous floods in St. Kitts. On Sunday, January 4, at 11.5 a.m., the inhabitants of Roseau, the capital of Dominica, a town situate on its western shores, were suddenly plunged into almost total darkness, for, although it had been raining heavily all the morning, the sky up to half-past ten was fairly clear, and there was no warning of what was to come except a strong smell of sulphur pervading the atmosphere, and this, in an island abounding in sulphur springs, is so usual that few of the inhabitants had even noticed it. With the strange darkness came torrents of milk-white water, mixed with black volcanic sand and ash, flashes of bright red lightning, peal after peal of thunder, while ever and anon between the peals could be heard a strange subterranean noise like the breaking of waves on a lee-shore. This lasted nearly fifteen minutes. When daylight was restored the town was found to be covered with ashes an inch deep, and the surrounding country presented a most abnormal appearance. The cause of this strange volcanic phenomenon did not long remain a mystery, for next morning, during a lull in the deluge of rain, there could be seen hanging over the "Boiling Lake" crater, and in clear outline against the sky, a cloud such as the younger Pliny describes as having hung over Vesuvius in August, 79, of our era. The now famous "Boiling Lake" of Dominica is the centre of a large crater in the southern extremity of the island, called the Grand Souffrière Hills. During the eruption nearly all the rivers in the island overflowed their banks, and in the Point Mulâtre River, which rises from the crater of the "Boiling Lake," all the fish, even those near to the estuary, died, and were subsequently taken out in basketfuls by the natives. The flood in St. Kitts occurred on Sunday, January 11. The storm began about 10 P.M with heavy rain, which gradually increased in intensity until midnight, when it almost seemed to be rain, and seemed to assume the character of a falling waterspout. During this time there were occasionally strong blasts of wind, very vivid lightning, and once or twice a tremulous undulating movement of the earth. There was, however, only one severe shock, and it is said to have occurred about 2.30 A.M. on the 12th, when the full fury of the storm was attained. After this it began to decrease in violence, and at 4.30 all was silent, and the work of destruction was over.

AN international exhibition of plants and flowers will be held at Weisbaden during the approaching summer.

AT Geneva an international exhibition of clocks and watches, and of all machines, implements, utensils relating to clock making, will be held during May and June next.

ICE-BLOCKS have been formed not only at Saumur but also at Lyons. These occurrences are not unexampled, as it appears that in the terrible winter of 1840 the Vistula was also blocked by ice, close to Dantzig; the result was that the stream opened a new bed in a sandy and hilly ground. The channel for preventing the level of water rising higher than the top of the embankments has been bored by explosions in the Saumur iceberg. The work was begun on the 16th and was ended on the 22nd. The section is from 10 to 20 metres. Since that time the engineers have been busy enlarging it, and the work is progressing favourably. The iceberg has been measured carefully, and estimated at 15,000,000 cubic metres. The navigation arm, on the right side, has been hopelessly blocked, and no work has been tried. The weather is splendid, the sun extremely hot during day, but the nights are very cold. On Tuesday morning all the streets were covered with ice.

IT has been noted that during the present weather crisis the Montsouris electrometers have shown not a single negative reading. This positive state has continued for the last three months. The readings are taken eight times a day.

THE recently opened Albert Institute at Windsor made a good beginning on January 20 with an interesting lecture by Mr. F. Drew, of Eton, on "The Objects aimed at by the Institute." Mr. Drew showed the great interest attaching to the study of the various branches of science, giving some useful practical hints as to how the study both of science and of literature may be most effectnally carried out.

WE notice a useful Russian work by M. Tchikoleff, on "The Electric Light and its Applications to Military Purposes," being a thorough description, with numerous figures of the various apparatus employed in the armies of various countries.

MR. GORDON HOLMES's work on "Vocal Physiology" is not published at Edinburgh, but by Messrs. Churchill, of London.

THE additions to the Zoological Society's Gardens during the past week include a Feline Dourocouli (*Nyctipithecus vociferans*) from Brazil, presented by the Right Hon. H. Hugh Childers, M.P.; an Ocelot (*Felis pardalis*) from British Guiana, presented by Mr. G. Whitmore Christie; a Little Grebe (*Podiceps minor*), British, presented by Mr. Thos. Edward Pryce; five Undulated Grass Parrakeets (*Melopsittacus undulatus*) from Australia, deposited; a Black Lemur (*Lemur macaco*) from Madagascar, a Tamandua Anteater (*Tamandua tetradactyla*) from Brazil, purchased.

OUR ASTRONOMICAL COLUMN

SOLAR PARALLAX FROM THE VELOCITY OF LIGHT.—Mr. D. P. Todd, of the *American Nautical Almanac* Office, publishes an interesting note upon this subject. Remarking that the opposition of Mars in 1862, when the planet approached near the earth, and the experimental determination of the velocity of light in the same year, mark the beginning of a new era in the history of the determination of the solar parallax, he refers to the many values of this constant which have since been worked out, and the fact that although theoretically the better class of these determinations should yield values in consistent harmony with each other, there are at present singular and unaccountable discordances. Prof. Newcomb's mean value of the parallax, 8″·848, he observes, was regarded with caution only because it was considered too small, the researches of Hansen, Leverrier, Stone, and Winnecke appearing to place the parallax considerably outside Newcomb's value. Within the last two or three years, however, Mr. Todd remarks that "the parallactic pendulum has swung quite to the lesser extremity of the arc until the true value of the solar parallax has appeared possibly below 8″·8, and that, too, with good reason." But now there seems to be a slight gravitation towards a central value, and he thinks it is not possible to say that the mean equatorial horizontal parallax of the sun is so much as the hundredth part of a second different from the old figure, 8″·813 (27″·2 centesimal) adopted by Laplace in the *Mécanique Céleste*, and resulting from the early discussions of the transits of Venus in 1761 and 1769.

Fizeau made the first experimental determination of the velocity of light in 1849, but the earliest which can lay claim to the merit of trustworthiness is that of Foucault in 1862, who found it 298,000 kilometres per second, expressing confidence in it to about one-six-hundredth part, though Mr. Todd estimates the probable error twice as great. Next we have the first determination by Cornu, detailed in the *Journal de l'École Polytechnique*, 1874, which is 298,500 kil. ± 1,000. The second determination by Cornu, related in the *Annales de l'Observatoire de Paris*, t. xiii., 300,400 kil. ± 300; Helmert's rediscussion of these experiments in 1876 assigns 299,990 kil., the probable error of which value Mr. Todd estimates at 200 kil. Then follow two determinations by Mr. A. A. Michelson, U.S. Navy, to the first of which, 300,100 kil., he assigns equal weight with the earlier value of Cornu; the second, briefly described in the *American Journal of Science* for November, 1879, Mr. Todd interprets, giving equal weight to the one hundred separate determinations, to imply a velocity of 299,930 kil. ± 100. Assigning weights to these various values, he finally deduces for the velocity of light, 299,920 kilometres, or 186,360 miles per second.

The next step for the determination of the distance of the sun from the earth is the combination of this value with astronomical constants: (I.) Theory and observation of Jupiter's satellites afford a result of the interval of time required by light in traversing the mean distance of the earth from the sun, but there are only two precise determinations of this interval, astronomically speaking; the first by Delambre in his Tables of the satellites, which was also adopted by Damoiseau in his later tables, published in 1836, the second by M. Glasenapp, of the Observatory of Pulkowa, in 1874, from twenty-five years' observations of the first satellite of Jupiter, ending in 1873; the values are respectively 493·2s., and 500·84s. ± 1·02s.; the latter value rests upon a much smaller number of observations than Delambre's, but Mr. Todd remarks that it is difficult to form a just estimate of the worth of an average observation of an eclipse of a satellite of Jupiter in the last century, and moreover, we have not the means of knowing the process of discussion followed by the French astronomer; he combines the result by giving double weight to Glasenapp's result, which depends upon observations of definite excellence, discussed with modern precision, and thus adopts 498·3s. for the time-interval required for light to reach the earth from the sun at her mean distance; he then combines the distance thus obtained with the value of the equatorial radius of the earth derived by Listing ("Neue geometrische und dynamische Constanten des Erdkörpers," Gottingen, 1878), and there results for the mean equatorial horizontal parallax of the sun 8″·802.

(II.) The velocity of light, the constant of aberration, the excentricity of the earth's orbit, and the earth's mean anomaly, are connected by an equation which Mr. Todd employs for a further determination of the solar parallax, adopting for the constant of aberration Struve's value (20″·4451), with Listing's value of the earth's equatorial radius, and by this process the sun's parallax is found to be 8″·811. Duly weighing the probable variations of the elements which enter into these computations, Mr. Todd concludes that the experimental determinations of the velocity of light hitherto made, give, when combined with astronomical constants, the mean equatorial horizontal parallax of the sun = 8″·808 ± 0″·006, and hence the corresponding mean radius of the terrestrial orbit = 92,800,000 miles.

FAYE'S COMET.—Although, as lately remarked in this column, the only known comet of short period which will be actually in perihelion during the present year is that discovered by Prof. Winnecke in 1858, Faye's comet will arrive at its least distance from the sun in January, 1881, and may be observed during the last half of 1880. Thanks to the admirable investigations of Prof. Axel Möller, the theory of Faye's comet is known with such precision that the ephemeris for the approaching reappearance, which he communicated to the Swedish Academy in September, 1878, and which has been reproduced in the *Astronomische Nachrichten*, may be expected to deviate in a very slight degree only from the truth, and the comet's discovery will be simply a test of the optical capacity of the telescope. Prof. Axel Möller commences his ephemeris on July 1, 1880, and continues it to the end of the year. On July 1 the theoretical intensity of light is 0·04, about equal to that at the date of the last observation with the 15-inch refractor at Pulkowa in 1844, and the comet in about R.A. 23h. 6m., Decl. + 8°, may be then observable. The maximum intensity will be attained about the middle of October, and will be about the same as at the last observation in 1858 with the 9-inch refractor at Berlin, or 0·21; at the end of the year the intensity of light will have diminished to 0·14. Thus the comet will be always faint, nor does it appear likely to present itself under the favourable circumstances attending its first appearance in 1843 for several revolutions yet to come.

GEOGRAPHICAL NOTES

BY a postscript to the February number of the Geographical Society's periodical we learn that a telegram has been received from Mozambique, announcing the arrival of the East African Expedition at Lake Tanganyika on October 28; the distance from Lake Nyassa was found to be 250 miles, the country level, and the people friendly. Mr. Thomson's account of his journey from Dar-es-Salaam to Uhehe is given in the present number, and his notes of the route, though necessarily somewhat rough, will afford useful material for filling up a blank in the map of East Africa. We have also Mr. Wilfrid S. Blunt's description of his visit to Jebel Shammar (Nejd), and his journey through Northern Arabia, of which he gave but an outline at a recent meeting of the Society. The paper is illustrated by two maps, one of which is a sketch map of Jebel Shammar furnished by Mr. Blunt. Among the geographical notes is an interesting account of Norwegian exploration last year in the Spitzbergen seas, which appears to have hitherto escaped notice in this country. Under the head of obituary we find brief notices of Major Herbert Wood, R.E., and Mr. Hepworth Dixon, while the remainder of the number contains the usual routine matter.

ACCORDING to the *Colonies and India*, Mr. Mitchinson, who has travelled much among the natives of nearly all parts of Africa, and especially in Berguela, Ovampo-, and Darnara-lands, &c., states that he saw there wild beasts which had been tamed entirely by the natives, although they are usually supposed never to attempt it. On the River Cunene he found two perfectly tame cow hippopotami, which were not confined in any way, but always returned to the village. In a neighbouring place Mr. Mitchinson also saw an African elephant which had been tamed, and was entirely under control. This certainly goes to show that the plan for utilising African elephants, to which we have before referred, is quite feasible.

AT a meeting which was held at Palmerston, in the Northern Territory, on the arrival of Mr. Alexander Forrest's expedition from West Australia, Mr. Hill, the second in command, and the geologist of the party, stated that it was painful to think how little had been done in the way of prospecting for minerals. He believed that a search in the north and west portions of the territory would well repay the trouble and that there was more mineral wealth in the neighbourhood than was imagined.

M. BRAU DE ST. POL-LIAS, the originator of the "Colons-Explorateur" scheme, has communicated to the French Geographical Society a letter which he has received from Dr. Rück, a missionary in Sumatra, in which he furnished the geographical results of a journey in the Batak country. His examination of Lake Tebah shows that there is no river flowing out at the north-east, as has been previously supposed, and that, contrary to earlier statements, there is a river flowing out of the south end of the lake, which is thought to empty into the sea on the east coast of the island, though its course does not appear to have been examined so far at present.

THE French Government have entrusted M. Th. Lécart with a "gratuitous" mission to investigate the ornithology and entomology of the region between the Senegal and the Niger, and MM. Brau de St. Pol-Lias and E. de Lacroix to collect ethnographical specimens in Sumatra.

M. SAVORGNAN DE BRAZZA, who is now on the west coast of Africa, has been entrusted by the French branch of the International African Association with the formation of their first station, which will probably be located on the upper waters of the Ogowé, where M. de Brazza has already made important geographical discoveries. Capt. Bloyet is to be the founder of the other station on the opposite side of the continent.

THE death at Ujiji is announced, of the French explorer, Abbé Debaize. The Abbé left Paris in March, 1878, with a subsidy of 10,000 francs from the French Government, to cross Africa, from Zanzibar to the west coast. He reached Lake Tanganyika in March of last year, after an unusually rapid and favourable journey. He intended to establish depôts at the north end of the lake, and at the mouth of Stanley's Aruwimi, to explore the country between the lake and the Albert Nyanza, and the region to the north of the Congo. He had started on his journey, but was so badly treated by his followers, that he returned downcast to Ujiji, where he died. The Abbé was well qualified by his scientific knowledge and his experience for the task he undertook, and his death is a real loss to the scientific exploration of Africa.

MR. STANLEY, according to information received by the Lisbon Geographical Society, had reached the last fall of the Congo at Yallala, and was preparing the installation of the first Belgian commercial station on the right bank of that river.

MESSRS. SONNENSCHEIN AND ALLEN have just published a "Primer of the Industrial Geography of Great Britain and Ireland," by Mr. G. Phillips Bevan. The Primer is likely to prove useful not only as a supplement to the ordinary school text-books, but to all who desire to have a knowledge of the geographical distribution of our multifarious industries.

THE Irkutsk mail informs us that M. Potanin returned on December 13 to that city. The results of his expedition are most important. He has thrown a quite new light on the geography and ethnography of North-western Mongolia. His assistant, M. Adrianoff, has made important geological explorations and obtained an interesting collection of ethnographical photographs. Besides, M. Orloff, who was sent to meet M. Potanin, has made several important surveys.

PERTHES, of Gotha, has issued on one large sheet an ingeniously tabulated and useful index to all the maps that have appeared in *Petermann's Mittheilungen*, from its first publication in 1855, down to the present. The index has been designed by Herr Bruno Hassenstein.

GEOLOGICAL NOTES

GEOLOGICAL SURVEY OF THE UNITED STATES.—Mr. Clarence King, the Director of the new Survey, has prepared his estimates for the appropriation of the $330,000 voted by Congress for the year ending June 30, 1880. They show generally how he proposes to distribute the work under his superintendence:—

Geological survey of iron and coal resources of public domain	$30,000
Extending observations on coal and iron into old States	20,000
Survey of agricultural geology on public lands of Mississippi Basin	25,000
Geological survey of gold and silver in Division of Rocky Mountains	35,000
Geological survey of gold and silver in Division of Great Basin	35,000
Survey of geological structure of public lands in Mississippi Basin	25,000
Survey of geological structure and classification of public lands of Rocky Mountains	30,000
Survey of geological structure and classification of public lands in Colorado Basin	40,000
Survey of geological structure and classification of public lands in Great Basin	30,000
Survey of geological structure and classification of public lands in Pacific	25,000
	$330,000

It will be observed that this allotment of the funds quite confirms the view lately expressed in our columns (NATURE, vol. xxi. p. 197) as to the "scare" which some of the geologists in the east have experienced on the subject of a proposed invasion of the old States by the forces of the new Survey. We ventured to point out that in the west Mr. King and his associates had such a vast and untouched field for their labours that they were not very likely to betake themselves to the well-beaten geological pathways of the Eastern States. Mr. King in the foregoing estimates proposes to devote only $20,000 for "extending observations on coal and iron into old States." Assuming that this item is inserted in good faith (and surely there is no reason to do otherwise), it must be regarded by impartial outsiders as reasonable and moderate. Probably the original intention was to secure power to prolong investigations from the public domain into surrounding States where this was required by the necessities of the service. No one will deny the propriety of such a provision. Even if the observations were to be extended into the Eastern States, so long as this was done merely with a view to acquiring information and experience to guide the field-operations in the Territories, it would surely still be within the province of any truly national Survey. That any serious attempt is contemplated to carry on ordinary geological surveying in the old States is simply inconceivable. So that again, in spite of their renewed protests, the geologists of the East may be urged to believe that they have the game in their own hands, and that they have no ground for alarm that the rights either of States or of private individuals will eventually suffer.

CATALOGUE OF OFFICIAL REPORTS OF AMERICAN GEOLOGICAL SURVEYS.—Mr. Frederick Prime, one of the assistant geologists in the Geological Survey of Pennsylvania, has just published, in the *Transactions* of the American Institute of Mining Engineers, a most useful catalogue of all the official reports issued up to the present time by the various geological Surveys of the States and Territories of the American Union, and of British North America. It thus forms a compendious guide to the official sources of information regarding almost all parts of North America, with the names of the authors and dates of publication.

THE PRIMEVAL CELL.—Some twelve years ago the petrographers and mineralogists of Germany were a good deal exercised in their minds by an escapade of one of their number—himself a very able mineralogist—who announced his discovery of a new microscopic fauna and flora in crystalline eruptive rocks, such as basalt and melaphyre. Of course, the presumed organic structures were repudiated by naturalists, and still remain characteristic products of the mineral kingdom. Another vagary of a similar kind has lately been perpetrated by Dr. Otto Hahn, who publishes a thin volume with a large series of plates, under the title of "Die Urzelle," in which he shows that everybody before him has unaccountably misunderstood the much discussed *Eozoon*, that it is neither a mineral nor an animal structure, but belongs to the vegetable kingdom! In the eozoonal limestones he finds numerous primæval sea-weeds, which, with paternal fondness, he takes care to have duly named. What a pity that so much time, labour, and ingenuity had not been more usefully employed!

MICROSCOPIC STRUCTURE OF SCOTTISH ROCKS.—Students of petrography may be interested to know that Mr. Bryson, of Edinburgh, has prepared for sale a series of sections of typical Scottish rocks, which have been selected for him by Prof. Geikie. They illustrate some of the most characteristic aqueous, igneous, and metamorphic rocks of Scotland. They are thirty in number.

MYTHOLOGIC PHILOSOPHY[1]

II.

RAIN.—The Shoshoni philosopher believes the domed firmament to be ice, and surely it is the very colour of ice, and he believes further that a monster serpent-god coils his huge back to the firmament, and with his scales abrades its face and causes the ice-dust to fall upon the earth. In the winter time it falls as snow, but in the summer time it melts and falls as rain, and the Shoshoni philosopher actually sees the serpent of the storm in the rainbow of many colours.

The Oraibi philosopher who lives in a pueblo is acquainted with architecture, and so his world is seven-storied. There is a world below, and five worlds above this one. Muingwa, the rain-god who lives in the world immediately above, dips his great brush, made of feathers of the birds of the heavens, into the lakes of the skies, and sprinkles the earth with refreshing rain for the irrigation of the crops tilled by these curious Indians who live on the cliffs of Arizona. In winter Muingwa crushes the ice of the lakes of the heavens, and scatters it over the earth, when we have a snow-fall.

The Hindoo philosopher says that the lightning-bearded Indra breaks the vessels that hold the waters of the skies with his thunderbolts, and the rains descend to irrigate the earth.

The philosopher of civilisation expounds to us the methods by which the waters are evaporated from the land and the surface of the sea, and carried away by the winds and gathered into clouds, to be discharged again upon the earth, keeping up for ever that wonderful circulation of water from the heavens to the earth and from the earth to the heavens, that orderly succession of events in which the waters travel by river, by sea, and by cloud.

Migration of Birds.—The Algonkin philosopher explains the migration of birds by relating the myth of the combat between Ka-bi-no-ke and Shingapis, the prototype or progenitor of the water-hen, one of their animal gods. A fierce battle raged between Ka-bi-no-ke and Shingapis, but the latter could not be conquered.

All the birds were driven from the land but Shingapis, and then was it established that, whenever in the future Wintermaker should come with his cold winds, fierce snows, and frozen waters, all the birds should leave for the south except Shingapis and his friends. So the birds that spend their winters north are called by the Algonkin philosophers "the friends of Shingapis."

In contrast to this explanation of the flight of birds may be placed the explanation of the modern evolutionist, who says that the birds migrate in quest of abundance of food and a genial climate, guided by an instinct of migration which is a cumulation of inherited memories.

Diversity of Languages.—The Kaibabit philosopher accounts for the diversity of languages in this manner: Si-chom-pa Ma-so-its, the grandmother goddess of the Sea, brought up mankind from beneath the waves in a sack, which she delivered to the Shinau-av brothers, the great wolf-gods of his mythology, and told them to carry it from the shores of the sea to the Kaibab Plateau, and there to open it, but they were by no means to open the package ere their arrival, lest some great disaster should befall.

The curiosity of the younger Shinau-av overcame him, and he untied the sack and the people swarmed out, but the elder Shinau-av, the wiser god, ran back and closed the sack while yet not all the people had escaped, and they carried the sack with its remaining contents to the plateau and there opened it.

Those that remained in the sack found a beautiful land, a great plateau covered with mighty forests, through which elk, deer, and antelopes roamed in abundance, and many mountain sheep were found on the bordering crags; *pive*, the nuts of the edible pine, they found on the foot-hills, and *use*, the fruit of the *Yucca*, in sunny glades, and *nant*, the *meschal* crowns, for their feasts, and *chuar*, the cactus-apple, from which to make their wine; reeds grew about the lakes for their arrow-shafts; the rocks were full of flints for their barbs and knives, and away down in the cañon they found a pipestone quarry, and on the hills they found arrarumpive, their tobacco.

Oh! it was a beautiful land that was given to these, the favourites of the gods. The descendants of these people are the present Kaibabits of Northern Arizona. Those who escaped by the way, through the wicked curiosity of the younger Shinau-av, scattered over the country and became Navahoes, Moquis, Sioux, Comanches, Spaniards, Americans—poor, sorry fragments of people, without the original language of the gods, and only able to talk in imperfect jargons.

The Hebrew philosopher tells us that on the plains of Shinar the people of the world were gathered to build a city and erect a tower, the summit of which should reach above the waves of any flood Jehovah might send. But their tongues were confused, as a punishment for their impiety.

The philosopher of science tell us that mankind was widely scattered over the earth anterior to the development of articulate speech, that the languages of which we are cognisant sprang from innumerable centres as each little tribe developed its own language, and that in the study of any language an orderly succession of events may be discovered in its evolution from a few holophrastic locutions to a complex language, with a multiplicity of words and an elaborate grammatic structure, by the differentiation of the parts of speech and the integration of the sentence.

Mythologic Philosophy has Four Stages.—Mythologic philosophy is the subject with which we deal. Its method, as stated in general terms, is this: All phenomena of the outer objective world are interpreted by comparison with those of the inner subjective world. Whatever happens, some one does it. That some one has a will, and works as he wills. The basis of the philosophy is personality. The persons who do the things we observe in the phenomena of the universe, are the gods of mythology—*the cosmos is a pantheon.* Under this system, whatever may be the phenomena observed, the philosopher asks, "Who does it? and why?" and the answer comes, "A god with his design." The winds blow and the interrogatory is answered, "Æolus frees them from the cave to speed the ship of a friend, or destroy the vessel of a foe."

The actors in mythologic philosophy are gods. In the character of these gods four stages of philosophy may be discovered. In the lowest and earliest stage everything has life, everything is endowed with personality, will, and design; animals are endowed with all the wonderful attributes of mankind; all inanimate objects are believed to be animate; trees think and speak; stones have loves and hates; hills and mountains, springs and rivers, and all the bright stars have life. Everything discovered objectively by the senses is looked upon subjectively by the philosopher and endowed with all the attributes supposed to be inherent in himself. In this stage of philosophy everything is a god. Let us call it *hecastotheism.* In the second stage men no longer attribute life indiscriminately to inanimate things, but the same powers and attributes recognised by subjective vision in man are attributed to the animals by which he is surrounded. No line of demarcation is drawn between man and beast; all are great beings endowed with wonderful attributes. Let us call this stage *zootheism*, when men worship beasts. All the phenomena of nature are the doings of these animal gods; all the facts of nature, all the phenomena of the known universe, all the institutions of humanity known to the philosophers of this stage, are accounted for in the mythologic history of these zoomorphic gods.

In the third stage a wide gulf is placed between man and the lower animals. The animal gods are dethroned, and the powers and phenomena of nature are personified and deified. Let us call this stage *physitheism.* The gods are strictly anthropomorphic, having the form as well as the mental, moral, and social attributes of men. Thus we have a god of the sun, a god of the moon, a god of the air, a god of dawn, and a deity of the night. In the fourth stage, mental, moral, and social characteristics are personified and deified. Thus we have a god of war, a god of love, a god of revelry, a god of plenty, and like personages who preside over the institutions and occupations of mankind. Let us call this *psychotheism.* With the mental, moral, and social characteristics in these gods are associated the powers of nature, and they differ from nature gods, chiefly in that they have more distinct psychic characteristics. Psychotheism

[1] From Vice-Presidential Address of Prof. J. W. Powell, of Washington, Vice-President Section B, American Association for the Advancement of Science, Saratoga Meeting, August, 1879. Continued from p. 314.

by the processes of mental integration develops in one direction into monotheism, and in the other into pantheism. When the powers of nature are held predominant in the minds of the philosopher through whose cogitations this evolution of theism is carried on, pantheism, as the highest form of psychotheism, is the final result; but when the moral qualities are held in highest regard in the minds of the men in whom this process of evolution is carried on, *monotheism*, or a god whose essential characteristics are moral qualities, is the final product. The monotheistic god is not nature, but presides over and operates through nature.

Psychotheism has long been recognised. All of the earlier literature of mankind treats largely of these gods, for it is an interesting fact that in the history of any civilised people the evolution of psychotheism is approximately synchronous with the invention of an alphabet. In the earliest writings of the Hebrews, the Egyptians, the Hindoos, and the Greeks, this stage is discovered, and Jehovah, Osiris, Indra, and Zeus are characteristic representatives. As psychotheism and written language appear together in the evolution of culture, this stage of theism is, consciously or unconsciously, a part of the theme of all written history.

The palæontologist, in studying the rocks of the hill and the cliffs of the mountain, discovers in inanimate stones the life forms of the ancient earth. The geologist, in the study of the structure of valleys and mountains, discovers groups of facts that lead him to a knowledge of more ancient mountains and valleys and seas, of geographic features long ago buried, and followed by a new land with new mountains and valleys and new seas. The philologist, in studying the earliest writings of a people, not only discovers the thoughts purposely recorded in those writings, but is able to go back in the history of the people many generations, and discover with even greater certainty the thoughts of the more ancient people who made the words.

Thus the writings of the Greeks, the Hindoos, the Egyptians, and the Hebrews, that give an account of their psychic gods, also contain a description of an earlier theism unconsciously recorded by the writers themselves. Psycotheism prevailed when the sentences were coined, physitheism when the words were coined. So the philologist discovers physitheism in all ancient literature. But the verity of that stage of philosophy does not rest alone upon the evidence derived from the study of fossil philosophies through the science of philology. In the folk-lore of every civilised people having a psychotheic philosophy, an earlier philosophy, with nature gods, is discovered.

The different stages of philosophy which I have attempted to characterise have never been found in purity. We always observe different methods of explanation existing side by side, and the type of a philosophy is determined by the prevailing characteristics of its explanations of phenomena. Fragments of earlier are always found side by side with the greater body of the later philosophy. Man has never clothed himself in new garments of wisdom, but has for ever been patching the old, and the old and the new are blended in the same pattern, and thus we have *atavism* in philosophy. So in the study of any philosophy which has reached the psychotheic age, patches of the earlier philosophy are always seen. Ancient nature gods are found to be living and associating with the supreme psychic deities.

Thus in anthropological science there are three ways by which to go back in the history of any civilised people and learn of its barbaric physitheism. But of the verity of the stage we have further evidence. When Christianity was carried north from Central Europe, the champions of the new philosophy, and its consequent religion, discovered, among those who dwelt by the glaciers of the north, a barbaric philosophy which they have preserved to history in the Eddas and Sagas, and Norse literature is full of a philosophy in a transition state, from physitheism to psychotheism; and mark! the people discovered in this transition state were inventing an alphabet—they were carving Runes.

Then a pure physitheism was discovered in the Aztec barbarism of Mexico, and elsewhere on the globe many people were found in that stage of culture to which this philosophy properly belongs. Thus the existence of physitheism as a stage of philosophy is abundantly attested. Comparative mythologists are agreed in recognising these two stages. They might not agree to throw all of the higher and later philosophies into one group, as I have done, but all recognise the plane of demarcation between the higher and lower groups as I have drawn it. Scholars, too, have come essentially to an agreement that physitheism is earlier and older than psychotheism.

Perhaps there may be left a "doubting Thomas" who believes that the highest stage of psychotheism—that is, monotheism—was the original basis for the philosophy of the world, and that all other forms are degeneracies from that primitive and perfect state. If there be such a man left, to him what I have to say about philosophy is blasphemy.

Again, all students of comparative philosophy, or comparative mythology, or comparative religion, as you may please to approach this subject from different points of view, recognise that there is something else: that there are philosophies, or mythologies, or religions, not included in the two great groups. All that something has been vaguely called *fetishism*.

I have divided it into two parts—*hecastotheism* and *zootheism*. The verity of zootheism as a stage of philosophy rests on abundant evidence. In psychotheism it appears as *devilism* in obedience to a well-known law of comparative theology, viz., that the gods of a lower and superseded stage of culture ofttimes become the devils of a higher stage.

So in the very highest stage of psychotheism we find beast devils. In Norse mythology we have Fenris, the wolf, and Jormungander, the serpent. Dragons appear in Greek mythology, the bull is an Egyptian god, a serpent is found in Zendavesta; and was there not a scaly fellow in the Garden of Eden? So common are these beast-demons in the higher mythologies that they are used in every literature as rhetorical figures. So we find, as a figure of speech, the great red dragon with seven heads and ten horns, with tail that with one brush sweeps away a third of the stars of heaven. And wherever we find nature worship we find it accompanied with beast worship. In the study of higher philosophies, having learned that lower philosophies often exist side by side with them, we might legitimately conclude that a philosophy based upon animal gods had existed previous to the development of physitheism, and philologic research leads to the same conclusion.

But we are not left to base this conclusion upon an induction only, for in the examination of savage philosophies we actually discover zootheism in all its proportions. Many of the Indians of North America, and many of South America, and many of the tribes of Africa, are found to be zootheists. Their supreme gods are animals—tigers, bears, wolves, serpents, birds. Having discovered this, with a vast accumulation of evidence, we are enabled to carry philosophy back one stage beyond physitheism, and can confidently assert that all the philosophies of civilisation have come up through these three stages.

And yet there are fragments of philosophy discovered which are not zootheistic, physitheistic, nor psychotheistic. What are they? We find running through all three stages of higher philosophy that phenomena are sometimes explained by regarding them as the acts of persons who do not belong to any of the classes of gods found in the higher stages. We find fragments of philosophy everywhere which seem to assume that all inanimate nature is animate; that mountains and hills, and rivers and springs, that trees and grasses, that stones, and all fragments of things are endowed with life, and with will, and act for a purpose. These fragments of philosophy lead to the discovery of hecastotheism.

Philology also leads us back to that state when the animate and inanimate were confounded; for the holophrastic roots into which words are finally resolved show us that all inanimate things were represented in language as actors.

Such is the evidence on which we predicate the existence of hecastotheism as a veritable stage of philosophy. Unlike the three higher stages, it has no people extant on the face of the globe known to be in this stage of culture. The philosophies of many of the lowest tribes of mankind are yet unknown, and hecastotheism may be discovered, but, at the present time we are not warranted in saying that any tribe entertains this philosophy as its highest wisdom.

THE NATURE OF ELECTRICITY[1]

On surveying the wide sea upon which the numerous and varied practical applications of electricity are launched for the subject of this evening's address, I have been puzzled to steer a course that shall avoid the dazzling shoals of theory on the one hand, and the dry hard rocks of practice on the other.

[1] Abstract of the Inaugural address to the Society of Telegraph Engineers, by Mr. William Henry Preece (President), delivered January 28, 1880. Revised by the Author.

Hypothesis is a veritable Scylla that captivates the imagination and often sends the visionary to destruction, while practice alone is a hard-hearted Charybdis that lures the matter-of-fact practical man to folly and expense. Practice must be tempered with theory to utilize advantageously the great forces of nature, and theory itself must be based on practice, or on facts, to be comprehensive and acceptable. Hence success is the offspring of the marriage of practice and theory, and, therefore, as the two are so intimately connected, I have determined to steer a middle course to-night to survey the progress of each in our profession, and to show their mutual relationship.

What is theory? It is an explanation of the hidden cause of certain effects that are evident to the senses. It is an effort of the imagination to account for operations that are in themselves invisible and insensible, but which result in facts that are observable and known. Thus the movements of all those bright bodies by which

> "the floor of heaven
> Is thick inlaid with patines of bright gold,"

are explained by the theory of gravity. Their appearance, vagaries, and beauties are accounted for by the undulatory theory of light. The warmth that the monarch of them all shed upon this earth countless ages ago, and that is now restored to us in our household fires, is explicable on the molecular theory of heat. The constitution of matter and its various states of solid, liquid, and gas, are completely explained by the atomic theory of Democritus and Dalton, and the modern kinetic theory of gases.

It is impossible for a practical man who has devoted more than a quarter of a century to the application of electricity to useful purposes, to avoid devoting much contemplation to the nature of the agent which he has to make use of. Is there a member of this society who has not striven to peer into the region of the unknown, who has not speculated on the power he uses, or who has not formed some conception in his mind of the nature of electricity? Yet it is remarkable that the answer to the question, What is electricity? cannot even now be given with authority. Faraday, our great apostle, whose researches should be every electrician's bible, declined to venture an answer, nor did he ever directly formulate his ideas on the subject, though his publications indicate pretty clearly and with no uncertain sound what they were. Clerk-Maxwell, who, while he overthrew all existing theories, failed to supply their place before he was so untimely removed from us. Sir William Thomson, in his published papers, always carefully eschews the consideration of any physical theory of electricity. The French electricians simply use the one-fluid theory as a convenience of language, while the Germans, as a rule, employ the two-fluid theory merely for mathematical purposes. Hence there is no recognised theory of electricity. Some maintain with Du Fay or with Franklin, that it is a form of matter—a substance; others, following Faraday and Grove, consider it a form of force—a motion—like heat and light. It must be either one or the other. There is no other category in which to class it. If it is not a form of matter it must be a form of force. The question I propose to discuss is, therefore, Is electricity a form of matter, or is it a form of force?

In discussing such a vexed question it is necessary to be very precise in language to avoid any misconception of my meaning, therefore I will define both matter and force in the sense in which I use those terms. *Matter* is that which can be perceived by the senses, or can be acted upon by force. It is characterised by weight, inertia, and elasticity. *Force* is that which produces, or tends to produce, the motion of matter. It may be pressure, tension, attraction, repulsion, or anything capable of causing alteration in the natural state of rest or of existing motion of matter.

Matter is found in either the solid, liquid, gaseous, or ultra-gaseous state, and it occupies space. It consists of molecules and atoms. The *atom* is the smallest indivisible part of an element, and a group of atoms of the same or of different elements forms the *molecule*, which has a definite magnitude and is unalterable in form for each substance. The *mass* of a substance is the aggregate of the molecules of which it is composed. There is no generation or destruction of atoms. The indestructibility of matter is a fixed law in nature. The size of the molecule is approximately known. Sir William Thomson says:—"If we conceive a sphere of water as large as a pea to be magnified to the size of the earth, each molecule being magnified to the same extent, the magnified structure would be coarser-grained than a heap of small lead shot, but less coarse-grained than a heap of cricket balls." Fifty million molecules ranged in single file would occupy an inch. They are highly elastic, and unless interfered with would move with constant velocity in straight lines. When they can move about freely without interfering with each other's proceedings, we have the ultra-gaseous state of Crookes, a state found only in very high vacua and under certain adventitious circumstances. When they collide and impinge on each other according to the law of the impact of elastic bodies, interfering with each other's path, we have *gases* as we know them; when their mean free path is so reduced as to bring them within the sphere of mutual attraction, without too narrowly restricting their play, we have *liquids*; when the attraction becomes cohesion and the motion of the molecule is confined to its own sphere, we have *solids*. The number of molecules in a given volume of gas is known, and their velocity calculated. In hydrogen the velocity at 0° Cent. is 6,097 feet per second, the number being 10^{23} per cubic inch. The mean free path of a molecule in air at ordinary pressures is the ten-thousandth part of a millimetre. Besides their constant motion in straight lines the molecules may be set in vibration, rotation, or any other kind of relative motion whatever.

This is the atomic theory of matter born in the brain of Democritus, "the laughing philosopher," 2,300 years ago; preached by Epicurus in Athens, and taught by Lucretius in Rome before the Christian era; lying dormant for eighteen centuries, until it was formulated by Dalton in the last century, and removed from the region of pure speculation by Joule, Clausius, Clerk-Maxwell, and Crookes during our days.

The definition of force shows us that whatever changes or tends to change the motion of matter (or of the molecules of which it is composed), by altering either its direction or its magnitude, is a form of force. Thus gravity is a form of force, for it attracts all matter to the centre of the earth, and it is measured by the rate per second at which a body acquires a velocity in this direction when falling freely at a given spot. Heat is a form of force, for it throws the molecules of matter into violent vibration, or it increases the velocity of their motion in straight lines, which thus becomes the measure of its heat or its *temperature*. Light is a form of force, for it is produced by the undulation of the molecules of matter, and it is transmitted by the undulations of that medium called Ether, which fills all space.

When we take a given free mass and impress upon it a given force, we throw that mass into motion; for instance, when we fire a loaded cannon, we have imparted to the ball "*energy*," and in virtue of the motion of the ball, this energy is called "*kinetic*." Again, if we lift the ball to a certain height above the earth's surface—say to the top of a tower—and let it remain there, we have again imparted to it "energy," but this time it is called "*potential*," for it is dormant or resting. In each case the energy possessed by the ball is the exact equivalent of the work done upon it, that is, of the force impressed and the distance through which it has acted. The motion of the ball is readily transferred to the motion of the individual molecules of the ball. When, in the first case adduced, the ball strikes the side of a ship or a target, its kinetic energy is thus converted into light and heat, which is molecular motion; or, in the second case, when it is allowed to fall, its potential energy is converted into kinetic energy, which again, on coming in contact with the ground, is converted into molecular motion or heat. Energy is always either potential or kinetic, and one of the most remarkable generalisations of modern days is the grand principle of the conservation of energy, which implies that the total energy of the universe is a quantity which can neither be increased nor diminished, though it may be transformed into any of the forms of which energy is susceptible. Energy is therefore as indestructible as matter. All the recent advances in the science of heat have been due to the discovery of this principle, and its application to electricity has gone far to remove that science from the hypothetical state in which it has existed so long.

My purpose is to contend that electricity is not a form of matter but a form of force, and that all its effects are evident to us in one or other of the several forms of energy characterised by the motions of molecules or of mass.

It is interesting to trace the historical growth of theories. The uncultivated human intellect cannot soar above its own limited sphere of childish observation. Whatever is mysterious and incomprehensible in nature is attributed to that which is equally mysterious and incomprehensible. Life has ever been of this character, and heat, magnetism, electricity, and many other unaccountable physical phenomena, have each in their turn been supposed to be causes of life. Even now there are those who would attribute exceptional and peculiar phenomena to spiritual agencies.

Heat was thought by the Greeks to be an animal that bit. It was then for many centuries thought to be a fluid which, entering into bodies, like mercury, made them swell, and this idea existed until this generation, when Rumford showed it to be a kind of motion, and Joule made it a quantitative form of energy.

Thales of Miletus thought that the magnet was endowed with a sort of immaterial spirit, and to possess a species of animation. The Greeks knew also that rubbed amber attracted bits of straw, and supposed it to be endowed with life. Even Boyle, as late as 1675, imagined it to emit a sort of glutinous effluvium which laid hold of small bodies and pulled them towards the excited body. Du Fay in 1733 conceived the double fluid theory, and Franklin in 1747 invented the single fluid theory. Cavendish in 1771 supplied some of the deficiencies of Franklin's theory, but it was Faraday who first exploded the fluid notion and originated the molecular theory of electricity, while Grove boldly classed electricity with light and heat as correlated forces and mere modes of motion.

Light was thought by the Platonists to be the consequence of something emitted from the eye meeting with certain emanations from the surface of things, but no theory of light properly so-called was attempted until Newton produced his celebrated corpuscular theory in 1670, which has lasted until the present day. Even as late as 1816 Faraday himself said—"The conclusion that is now generally received appears to be, that light consists of minute atoms of matter of an octahedral form, possessing polarity, and varying in size or in velocity."[1] Although Huyghens in Newton's own time conceived the undulatory theory, the superior authority of the great English philosopher overshadowed the lesser light, and it was not until Young and Fresnel at the commencement of this century took the matter up, that the present theory of light took firm root.

Thus we see that all these sciences have passed through the same stages of mystery and fancy, and it is only within the present generation that they have emerged from the mythical to the natural, from mere hypothesis to true theory. *Hypothesis* is an imaginary explanation of the cause of certain phenomena which remains to be shown probable or to be proved true. *Theory* is this supposition when it has been shown to be highly probable and all known facts are in agreement with its truth.

A theory, therefore, to be valid and true, must agree with every observed fact; it must not conflict with natural laws; it must suggest new experience, and it should lead to further developments. A theory is absurd if it supposes an agent to act in a manner unknown in all other cases. The fluid theories of electricity are merely descriptive, they do not agree with every observed fact; they have never prompted the invention of a single new experiment, or led to any development. They suppose an agent unknown in other cases and opposed to natural laws. Incomplete theories die a natural death: thus Descartes' vortices, Newton's corpuscular theory of light, the fluid theory of heat, Stahl's phlogiston, Nature abhorring a vacuum, have all disappeared, while complete theories, such as that of gravity, the laws of motion, the conservation of energy, the undulatory theory of light, not only remain, but suggest new fields of inquiry, open out fresh pastures, carry truth and conviction with them, and have led to the most wonderful predictions. The fluid theories of electricity are certainly incomplete, and they deserve a speedy interment. We have to assume the existence of two substances of opposite qualities which mutually annihilate each other on combination—a self-evident absurdity, for the conception of matter involves indestructibility. Franklin imagined his one fluid to be an element of glass; remove electricity, and glass would lose its virtues and properties, and thus glass was to give out its electricity for ever and a day, without loss of weight or sensible diminution. It was to be devoid of dimensions, inertia, weight, and elasticity, and is therefore outside the pale of our definition.

Electricity is therefore not a form of matter. Hence, according to our reasoning, it must be a form of force.

But can we not prove that it is a form of force? Certainly.

Let us first argue from analogy. We know that sound, heat, and light are modes of motion; in what respects does electricity agree with these forms of force?

1 "Life," vol. i. p. 216.

The fundamental law of electrostatics is that two bodies charged with opposite electricities attract each other with a force dependent on the square of the distance separating them. Whatever influence or power spreads from a point and expands uniformly through space varies in intensity as the square of the distance for the area over which it is spread increases as the square of the radius. This is the case with gravity, light, sound, and heat, which are known forms of force. It is also the case with electricity and magnetism, which ought therefore to be similar forms of force.

If we regard the velocity of transmission of certain electrical disturbances through space, we have every reason to believe that it is the same as that of radiant heat and light. In 1859 two observers in different parts of the country (Messrs. Carrington and Hodgson) saw simultaneously a bright spot break out on the face of the sun, whose duration was only five minutes. Exactly at this time the magnetic needles at Kew were jerked, and the telegraph wires all over the world were disturbed. Telegraphists were shocked, and an apparatus in Norway was set on fire. Auroras followed, and all the effects of powerful magnetic storms. Moreover, the periods of sun-spots, earth currents, and magnetic storms follow the same cycle of about eleven years. Dr. Hopkinson has shown that this electric disturbance through space is as mechanical as its action through short distances, and is therefore identical with the ordinary strains of elastic matter subject to distortion by mechanical force. But Clerk-Maxwell has gone beyond this, and has shown that the velocity of light is identical with that of the propagation of electrical disturbances through space as well as through air and other transparent media. Hence, as light is admitted to be a mode of motion identical with radiant heat, electricity must be of the same category.

There is such a remarkable analogy between the conductivity of the different metals for heat and for electricity—indeed, there is every reason to believe that if the metals were pure, the order and ratio of conductivity would be identical—that it is impossible to resist the conclusion that the mode of transmission in each case is the same. Mr. Chandler Roberts, who, using Prof. Hughes' beautiful induction-balance, showed, by experiments on a comprehensive series of alloys, that the curves indicating the induction-balance effect closely resemble their curves of electrical resistance. He was also able to demonstrate that the induction-balance curve of the copper-tin alloys is almost identical with the curve of the conductivity of heat:—a conclusion of much interest; and he pointed out that we might look with confidence to being able to ascertain, by the aid of the induction-balance, whether the relation between the conductivity of heat and electricity is really as simple as it has hitherto been supposed to be. Moreover, when a wire conveys a current of electricity it is warmed, as the strength of current is increased it is heated and eventually rendered incandescent. The ultimate form which every electric current takes is heat. The wire of every telegraph is warmed in proportion to the currents it transmits. Joule showed that when this heat is produced by a current generated in a battery by chemical force, its amount is exactly equivalent to that which would have been evolved by the direct combination of the atoms. The conducting power of all bodies is affected by heat, and some even, like selenium, by light. Hence, as we know that in the case of heat and light conduction is molecular vibration, we reasonably conclude that it is the same with electricity. In fact, it is impossible to account for these phenomena except on the assumption of the motion of the molecules.

The magnificent researches of Dr. Warren de la Rue and Dr. Hugo Müller on the electric discharge with the 11,000 cells of chloride of silvery battery that the former philosopher has provided himself with in his celebrated laboratory, have shown indisputably that the discharge in air or in gases under various pressures is a function of the molecules filling the space through which the discharge occurs. In fact, the resistance of the discharge between parallel flat surfaces is as the number of molecules intervening between them; and they show that during electrical discharge in a gas there is a sudden and considerable pressure produced by a projection of the molecules against the sides of the containing vessel distinct from that caused by heat, and unquestionably due to the molecular action of electrification. The long-continued and patient researches which these eminent physicists are carrying out prove beyond doubt that electrical discharge is simply molecular disturbance. In reality, the fact that no discharge occurs through a perfect vacuum is a crucial proof of the molecular theory.

Some recent very remarkable researches of M. Planté with his rheostatic machine[1] have shown that fine wires conveying powerful currents are wrinkled up into well-defined regular nodes, that these effects are accompanied by a peculiar crackling, and that the wire itself becomes brittle, giving clear indication of the vibratory motion of the molecules. He gives as the result of his inquiry that electrical transmission is the result of a series of very rapid vibration of the more or less elastic matter which it traverses, and he points out certain analogies between electric motion and sonorous vibrations. This view is supported by the researches of Professors Ayrton and Perry[2] on the viscosity of dielectrics.

Prof. Challis, of Cambridge, has extended this view so far as to embrace magnetism, electricity, light, heat, and gravity in one category of physical force, and to assert that they all result from motions and pressures of a uniform elastic fluid medium pervading all space not occupied by atoms. His views, however, have not received much attention, for they are not based on the foundation of any new facts, and they are utterly subversive of many cherished principles deeply rooted in the scientific mind. It is to be observed, however, that he regards electricity as a form of force.

Mr. Crookes, in his recent beautiful experimental researches into molecular physics in high vacua, has still more conclusively proved the connection that exists between electrical action and molecular motion. In fact, his experiments are so brilliant, his expositions so lucid, that one can fancy one sees with the eye of the body that peculiar play of the molecules which can be evident only to the eye of the mind. Not only has Mr. Crookes established as a physical fact the kinetic theory of gases and the molecular constitution of matter, but he has indicated the existence of a fourth state of matter where the molecules fly about without mutual let or hindrance. He has also led us to doubt the truth of the generally received opinion that an electric current flows from the positive to the negative electrode. It would appear from his investigations that the reverse is the case. Be that as it may, he has added one story to the structure of the molecular theory of electricity.

The criterion of a good theory is, however, its power of prediction. A false theory has never led to prevision. Neither the corpuscular theory of light, nor the fluid theories of heat and electricity, ever led to the prediction of something of which eyes had not seen nor ears heard. The triumphs of prediction in astronomy, sound, light, and heat are innumerable. Faraday predicted the effect of induction in lowering the velocity of currents of electricity and the action of magnetism on a ray of light. Sir William Thomson predicted that a current in passing from a hot to a cold part of a copper bar would heat the point of contact, while in an iron bar it cools it. Peltier predicted the cooling effect of currents on the junctions of thermoelectric pairs.

But the true identity of these physical effects is conclusively shown by their quantitative character and by their adhesion to the law of the conservation of energy. Take the case of the electric light: the consumption of coal in a furnace generates steam, the steam works an engine, the engine rotates a coil of wire in a magnetic field, the motion of the coil in this field induces currents of electricity in the wire, these currents of electricity produce an arc, and thereby heat and light. The energy of the coal is transformed into heat and light through the intermediate agency of electricity. Is it possible to conceive that this intermediate agency is anything but a form of energy? Take the case of the Bell telephone: the energy of the voice produces the energy of sonorous vibration in the air, the vibrations of the air cause the vibrations of the iron disk, the vibrations of the disk vary the magnetism of the magnetic field, this produces currents of electricity in a small coil in this field which vary the magnetism of the distant magnet, which in its turn throws its disk armature into vibration, and thereby repeats at the distant station the sonorous vibrations of the air, and thus reproduces the energy of the voice. A tuning fork comes to rest sooner in front of a telephone than when it is allowed to vibrate freely in air. Here we have the energy of the fork passing through the several stages indicated above, and ultimately coming out in its original form. The energy of sonorous vibrations at the distant station is that lost by the vibrating tuning fork.

Is it possible to assume that in this cycle of changes energy has been transformed into matter and matter again formed into energy? It is impossible and absurd. Clerk-Maxwell said—

[1] *Comptes Rendus*, lxxxix., pp. 76–80, 1879.
[2] *Proc.* Roy. Soc. pp. 7–8, 1878.

"When the appearance of one thing is strictly connected with the disappearance of another, so that the amount which exists of the one thing depends on and can be calculated from the amount of the other which has disappeared, we conclude that the one has been formed at the expense of the other, and that they are both forms of the same thing."

Would it be possible to light the streets of New York by the energy of the falling water at Niagara, as has been suggested by our Past President, Dr. Siemens, if the cycle of changes from the one spot to the other were not all different forms of this same energy? Would it be possible to plough a field a mile away from the source of motive power of the transmitting medium if the electric currents were not forms of the same power? Electricity in its effects is and must be a form of energy.

The final stage into which any physical theory grows is that in which every action can be expressed in mathematical language, where every phenomenon is calculated upon an absolute physical basis, and where we can foretell exactly what will occur under any possible emergency. This is the present condition of the science of electricity. We can calculate exactly how much steam power is required to generate a given current to produce a given light. We can tell precisely what dimensions of cable are necessary to give a certain number of words per minute on the other side of the globe. If a fault develop itself in a long cable through the gastronomic propensities of a thoughtless young teredo, we can calculate to within a few fathoms the locality of his edacious depredation.

Clerk-Maxwell,[1] in his classical work on electricity, has used a somewhat curious argument to show that electricity is not, like heat, a form of energy. He says that energy is produced by the multiplication of "electricity" and "potential," and that it is impossible that electricity and energy should be quantities of the same category, for electricity is only one of the factors of energy, the other factor being "potential." But this does not militate in any way against the force of the argument, for in nature we can no more do so than we can separate heat and temperature. Energy usually appears as the product of two factors, and it is the equivalent of the work done. Thus, *Potential energy* is the product of mass and gravitation acting through a distance. *Kinetic energy* is the product of mass and the half-square of velocity. The energy of fluids is the product of volume and pressure. The energy of heat is made up of heat and temperature, and the energy of electricity is the product of electricity and potential. Hence it is that electricity, *per se*, may be said to be a form of force, while all its effects as known to us are forms of energy. Force alone cannot produce energy; it must be force and something else. Force is the power of producing energy, and it must have something on which to produce it. Hence matter is always present; and thus, though heat, light, and electricity are forms of motion, they are in reality properties of matter from which they are inseparable. They are evident to us through the play of the molecules of matter, and thus are properly called molecular forces.

Earth currents have been a favourite subject of inquiry of mine for many years. I have always entertained the idea that they are directly due to the action of the sun. Some disturbance in the sun causes, by induction, a variation in the distribution of the lines of potential on the earth's surface, and produces the conditions required for these currents. I have many facts to support this hypothesis, but I want more to confirm it. Profs. Ayrton and Perry have developed a theory of terrestrial magnetism based on the assumption that the earth is a highly electrified sphere, which not only coincides well with facts, but which tends greatly to support my views. I want observers to record the times of daily maxima and minima. I want them especially to note during those periods of unusual disturbance the direction of the circuits which are *not* affected, for they would give the direction of the lines of equi-potential. This not only offers a useful field of observation, but its failure or success will illustrate the modern method of scientific research, when the brain suggests to the hand and the eye what they have to do, and what they have to look for.

Mr. Preece then went on to speak of the educational work of the Society and to notice some of the recent practical applications of electricity, and in speaking of the telephone stated that litigation has commenced between the Post-Office and the telephone companies not to restrict or in any way to interfere with the use of the telephone, but to prevent the establishment of a

[1] Vol. i., p. 30.

particular branch of post-office telegraph business with its licence or consent.

Mr. Preece in conclusion congratulated the Society on its great success.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—The Cambridge mathematical tripos this year contains 102 names. There are 33 classed as wranglers, 33 as senior optimes, 33 as junior optimes, and 3 ægrotant. In 1879 the list contained 91 names: 28 wranglers, 33 senior optimes, 29 junior optimes, and 1 ægrotat. The senior wrangler, Mr. Joseph Larmor, of St. John's, is a native of Belfast, and was born in 1857. He was educated at the Royal Academical Institution and Queen's College, Belfast. In 1874 he graduated at the Queen's University, Belfast, obtaining a double first in mathematical and experimental sciences, with two gold medals and exhibitions. He obtained similar distinction when he became M.A. In 1876 he entered the University of London, where he obtained an exhibition for mathematics, subsequently being awarded the Arnott exhibition and medal in experimental physics. At the first B.A. examination in 1878 he obtained the University scholarship in mathematics. He subsequently proceeded to the degree of B.Sc. In 1876 he obtained an open scholarship at St. John's, and has been on several occasions a prizeman at the college examinations. The next in order are Mr. Joseph John Thomson, of Trinity College; Mr. Walter Burt Allcock, a scholar of Emmanuel; and Mr. Homersham Cox, of Trinity. It is remarkable that the senior wranglers of two successive years have been from Queen's College, Belfast.

Among the wranglers this year, if the list had been complete, Miss Scott of Girton College would have been bracketed eighth wrangler. Moreover, she is younger than many of the wranglers, being still under twenty-two. Possibly she may go in for the Smith's Prize examination, although in the present state of regulations it would be impossible to award it to a lady. Nevertheless this achievement must be one more blow to those who would persistently keep ladies from having Cambridge degrees. Miss Scott intends to proceed to a degree at London University in physics. The fourth place in the first class of the recent moral sciences tripos was secured by Miss Martin of Newnham; and it is said that the only names in the first class in the historical tripos were those of two lady students, also of Newnham. No men were placed in the first class in this tripos.

Prof. Stuart reopens his workshop at Cambridge this term, and there will be practical instruction in the use of tools in iron and wood which will be provided, and also more advanced classes for those who have already acquired a knowledge of the use of tools. Classes will be formed in mechanism, engineering, drawing, applied mechanics, theory of structures and the application of higher mathematics to engineering. The professor means to found a first-class school for civil and mechanical engineering, and evidently intends to leave no stone unturned to accomplish this object, as well as to teach candidates for the University examinations.

Mr. Garnett will lecture on heat in the Cavendish Laboratory on Mondays, Wednesdays, and Fridays, this term.

OXFORD.—In a congregation held on the afternoon of February 3, Mr. Vernon Harcourt's amendment to the form of statute, respecting degrees in Natural Science came on for discussion. It will be remembered that the preamble of the statute alone remains, enacting that it is expedient for the University to grant degrees in Natural Science. When it appeared by counsel's opinion that the new degree in Natural Science would not confer on the graduate the privileges of a member of convocation, all the clauses of the proposed statute were rejected after a close division last term. Mr. Harcourt's proposal was to insert a clause in the statute to the effect that "every person who shall have been admitted to the degree of Natural Science shall also be admitted to the degree of Master of Arts." This proposal was defeated by a large majority, 27 voting for it, and 110 against it.

The examiners for the Burdett-Coutts geological scholarship have given notice that the examination will commence on Monday, February 16, at 10 a.m. The scholarship is tenable for two years, and is open to all members of the University who have passed all the necessary examinations for the B.A. degree, and shall not have exceeded their twenty-seventh term. The examiners are Prof. Prestwich, Dr. Odling, and Mr. Hatchett Jackson.

There will be an election to at least one junior studentship in natural science at Christ Church, on February 21. Candidates must not have exceeded the age of twenty on January 1, 1880. Papers will be set in chemistry, biology, and physics, but no candidate will be allowed to offer himself in more than two of these subjects. The examination begins on February 11.

The composition of the governing body of the French University has been the occasion of protracted and violent debates in the French Senate. It was only by a few votes that M. Ferry obtained its secularisation and expelled all ministers of every denomination.

The Geneva University numbers now 525 students and assistants, 134 more than last year, of whom 106 are in the faculty of science, 208 in that of literature, 35 in philosophy, 15 in theology, 54 in law, and 107 in medicine; 125 are Swiss, strangers to Geneva, and 200 foreigners.

We learn from a paper just published in the *Journal* of the Russian Ministry of Public Instruction that the number of scholars in all Russian colleges (gymnasia) reached 53,072 in 1878. But the figures as to the number of scholars who have terminated their studies in colleges are very unsatisfactory. Out of 57,917 scholars who entered the colleges during six years (1872 to 1877), only 6,511, *i.e.*, 2·5 per cent. terminated their studies, 51,406 having left the colleges without having received attestations of maturity. In "Real" schools, where the whole education is based on the study of natural science instead of that of language, the percentage is far more satisfactory.

SCIENTIFIC SERIALS

Zeitschrift für wissenschaftliche Zoologie, 33 Bd. 3 Heft, December, 1879, contains:—Conrad Keller, studies on the organisation and development of *Chalinula fertilis*, pl. 18 to 20.—Dr. G. Haller, contributions towards a knowledge of the *Læmodipodes filiformes*; commencing with a very careful and detailed account of the anatomical details to be met with in that group, it proceeds to an account of the life-history of the species, with a paragraph on their mimicry, under the heading "Darwinia": among the epizootic animals described is a very curious new species of Podophrya, with a long tapering and transversely striated stalk, and possessing a nucleus, with nucleolus, and to this follows the systematic portion, in which several new species of Proto, Caprella, and Podalirius are described and figured, pl. 21 to 23.—Olga Metschnikoff, on the morphology of the pelvic and shoulder girdles in cartilaginous fishes, pl. 25 and 26. —A. Gruber, on new infusoria, describes a number of new genera of fresh water infusoria.—Prof. Selenka, on a siliceous sponge with an octoradiate structure, and on the development of sponge-offsets, pl. 27 and 28.

Nyt Magazin for Naturvidenskaberne, 25de Binds, 2det Hefte, 1879.—D. C. Danielssen and J. Koren, the echinoderms of the Norwegian North Sea Expedition. Several very remarkable new genera and species belonging to the Holothuriadæ are described and excellently figured in this part.—Leonard Stejneger, contributions towards the Western ornithological fauna.

Journal de Physique, January.—On the thermal laws of the electric spark in gases, by Prof. Villari.—Projection of images formed between two plane mirrors, by Prof. Bibart.—On the compressibility of air and carbonic acid at 100°, according to M. Regnault's experiments, by M. Bouty.—Chloride of lime battery, by M. Niaudet.—Photometric researches on coloured flames, by M. Gouy.—New producer of electricity based on capillarity, by M. Debrun.

Reale Istituto Lombardo di Scienze e Lettere, Rendiconti, vol. xii., fasc. xx.—On the structure of the peripheric and central medullated nerve fibres, by Prof. Golgi.—On the temperature and humidity of the air, and the formation of dew in the neighbourhood of great lakes, by Prof. Cantoni.—On the conditions of most suitable form and exposure of evaporimeters, by the same.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, January 15.—"Results of an Inquiry into the Periodicity of Rainfall." By G. M. Whipple.

The author has collected the following series of rainfall observations, all of which contain more than fifty years' records.

Station.	Periods.	No. of years.	Authority.
Paris	1639–95, 1699–1754, 1773–97, 1804–75..	161	Annuaire de l'Observatoire de Montsouris, 1879.
Padua...	1725 to 1878	154	MSS. from P. Denza.
England (Symons' table)	1726 to 1865	140	B.A. Report, 1866.
Milan	1764 to 1878	115	MSS. from P. Denza.
London	1813 to 1878	66	Dines and Symons.
Madras	1813 to 1877	65	NATURE, vol. xviii. p. 565.
Philadelphia ...	1810 to 1867	58	Smithsonian Tables, p. 97.
Edinburgh	1822 to 1878	57	NATURE, vol. xviii. p. 97.
New Bedford ...	1814 to 1867	54	Smithsonian Tables, p. 90.
Rome	1825 to 1878	54	MSS. from P. Denza.

To these he added an eleventh, forming a series by combining together the annual rainfall for 1822 to 1875 at London, Paris, and Edinburgh, which increased the total number of years of observations to 978.

These he has discussed after a method described at length in the paper, and determined for every series the curves which represent the variation in the means of the amount of annual rainfall for each of the years comprising the series on the assumption of the presence of a cycle, which he varies in duration from five to thirteen years.

The computed curves are then compared with the actual curves representing the observations, and the number of coincidences and non-coincidences in the epoch of maximum and minimum determined.

The results show that in no one case is there any indication of a period of any integral number of years from five to thirteen inclusive running through them.

It also became evident that for the same epoch the curves of variation differ widely for localities comparatively close together. For example, taking the eleven-year cycle for Padua and Milan, stations only about 130 miles apart, both well situated for observing rain, and no mountain range intervening, the variation curves are as follows:—

Year...	1800 +11*n*	1801 +11*n*	1802 +11*n*	1803 +11*n*	1804 +11*n*	1805 +11*n*	1806 +11*n*	1807 +11*n*	1808 +11*n*	1809 +11*n*	1810 +11*n*
Padua.	−1·3	−0·3	−1·7	+1·1	+4·2	+4·2	−4·9	+3·4	−2·8	−2·8	+1·7
Milan.	−5·0	+1·5	+0·2	−1·9	−2·5	0·c	+3·0	+4·7	−5·6	+2·6	+3·3

These show that the years of greatest rainfall at Padua are represented by the formula [1804 or 5 + 11*n*], and of least by [1806 + 11*n*], whilst for Milan the maximum occurs at [1807 + 11*n*], and the minimum at [1808 + 11*n*].

Numerous other instances of incongruity are found in every one of the cycles, leading forcibly to the conclusion that either no short term of exactly five, six, seven, eight, nine, ten, eleven, twelve, or thirteen years exists in the annual amount of rainfall at any of the stations whose observations have been discussed in the paper, or that the effect of abnormal falls is so great that it cannot be eliminated by upwards of a hundred years' observations.

In any case the author thinks it may now be stated with certainty that all predictions as to rainy or dry years, based upon existing materials, must in future be considered as utterly valueless.

Zoological Society, January 20.—Prof. Flower, F.R.S., president, in the chair.—Mr. H. N. Moseley exhibited and made remarks on some microscopic preparations of corals made by a new method invented by Dr. G. V. Koch.—Prof. Flower, F.R.S., read a letter addressed to him by Col. Heysham, of the Madras Commissariat Staff, giving particulars of two cases of female elephants, in India, having produced young in captivity.—Dr. A. Günther, F.R.S., exhibited and made remarks on a drawing of a West Indian fish (*Holacanthus tricolor*) obtained on the coast of the Island of Lewis, and believed to have been found for the first time in the British Seas.—Mr. P. L. Sclater read some remarks on the species of the genus *Tyrannus*, in relation to a paper on this subject recently published by Mr. Ridgway, in America.—A communication was read from Mr. Roland Trimen, containing an account of a new species of Roller (*Coracias*), from the Zambesi, which he proposed to name *C. spatulata*, from its long spatulated tail.—A communication was read from Mr. Alexander Agassiz, of Cambridge, Mass., containing notes on some points in the history of the synonomy of Echini, in reference to some papers recently published by Mr. Bell in the Society's *Proceedings*.—A paper was read by Mr. F. Moore on the genera and species of the lepidopterous sub-family *Ophiderinæ*, inhabiting the Indian region.

Physical Society, January 24.—Prof. W. G. Adams in the chair.—New member, Mr. W. Ellis.—Mr. Grant read a paper and exhibited experiments on induction and telephonic circuits. He was led to these experiments by a former observation that when an induction coil primary was placed in a circuit consisting of a telephone, microphone, and battery, the microphonic sounds heard in the telephone were increased on closing the secondary circuit of the coil. Employing a double round coil, that is having primary and secondary side by side, he found that the latter could act as a condenser, and "relay" or translate messages into a second circuit, the microphone and battery being in the circuit of one wire (*i.e.*, the primary), the other wire (or secondary) containing a telephone. He also inserted a double normal coil in the latter or secondary circuit, and caused the induced or translated current to flow through both of the wires of this double coil one after another in the same direction. The effect was weak; but on reversing the current in one-half of the double coil by means of a commutator, so as to make it double on itself as it were, the weakening effect of induction was neutralised, and the sounds heard were as loud as if no coil had been inserted in the secondary circuit at all, as was proved by short circuiting the double coil altogether.—Dr. O. J. Lodge read a paper on intermittent currents and the theory of the induction balance. The telephone, as a scientific instrument, seems destined to play an important part as a detector of minute currents of rapidly changing intensity, and the general theory of intermittent currents is being brought into prominence by its use. The equations to which most attention has been hitherto directed have been those relating to the steady flow of a current after the initial inductive or inertia-like effects have subsided. The galvanometer is essentially an instrument for measuring steady currents or for giving the algebraically integrated expression for the total quantity of electricity which has passed in the case of transient currents. But the telephone plate has a very small period of swing compared to a needle, and, moreover, the plate is not limited to one mode of vibration like the needle. The induction balance was used experimentally by Dove and Felici, but was not appreciated as an instrument of research till Prof. Hughes applied it to the telephone and an intermittent current. The general theory of the establishment of a current in circuits of known resistance was given by Thomson, and is to be found in Maxwell's "Electricity." Dr. Lodge used this theory in order to work out the theory of the induction balance and one or two other cases of intermittent currents as completely as possible without taking into account the electrostatic capacity of wires and leakage. The current in either primary of the balance is the same, and the current in either secondary is the same at every instant of time. In fact, the separating of the two halves of the circuits is immaterial to the theory. The current induced in the secondary circuit is a tertiary current induced from the piece of conducting matter inserted between the primary and secondary, an expression being got for the strength of current in the telephone at any instant after a change in the resistance of the primary has occurred. The author deduces among other things the law according to which a small coin, by its position and size, disturbs the balance. Dr. Lodge remarked that Prof. Hughes, either by inventive intuition or great pains, had hit upon the best form of the apparatus for his purpose. The paper, which is very complete, is to be published in the *Philosophical Magazine* for February.—Herr Faber then exhibited his new speaking machine which is designed to imitate mechanically the utterances of the human voice by means of artificial organs of articulation, made on the human model, and actuated by an operator who depresses certain keys as in playing a musical instrument. These organs are a bellows made of wood and india-rubber, which answers to the lungs; a small windmill brought in front of the latter to give the "r," or trilling sounds, a larynx of hippopotamus hide and india-rubber having a vibrating end, to give the "drone" or basic tone of the voice, a mouth with two lips, a tongue, and a nose or proboscis made of india-rubber tubing, placed below the mouth, but curving up towards it. Fourteen distinct vocal sounds can be uttered by the instrument, but in combining these, any word in any language can be played by the keys. Thus Herr Faber caused his machine to say such words as "Mariana," "Eliza," "Philadelphia," "Constantinople," and various sentences in French, English, and German, more or less distinctly. Laughing and whispering were also produced, and the voice of the instrument which was ordinarily loud and clear, and resembling that of a girl, was lowered in pitch and loudness to a more masculine tone.—Mr. C. Boys exhibited "a liquid voltaic arc" formed of a liquid bead of oxide of iron between two platinum electrodes connected to the poles of twelve Grove cells. The arc emitted a brilliant light, which was intensified by tincturing the glowing drop with glass so as to form a compound silicate of iron.

Manchester

Literary and Philosophical Society, December 16, 1879.—J. P. Joule, LL.D., D.C.L., F.R.S., &c., president, in the chair.—On a new form of marine rain gauge, by W. J. Black. Communicated by J. B. Dancer, F.R.A.S.—On screw propulsion, Part III., by Robert Rawson, Assoc. I.N.A., Hon. Member of the Manchester Literary and Philosophical Society, Member of the Mathematical Society.—On the anal respiration of the copepoda, by Marcus H. Hartog, M.A., B.Sc., F.L.S.

Edinburgh

Royal Society, January 19.—Prof. H. C. Fleeming Jenkin, vice-president, in the chair.—Part of the material employed by Principal Forbes in tamping the bore for his earth-thermometers was exhibited in its metamorphosed state. An explanatory note from Prof. Piazzi Smyth, Astronomer-Royal for Scotland, was read, and the various specimens of rock and hardened "clay-puddle" were committed to the care of Mr. Murray, of the *Challenger* Expedition, who offered to prepare microscopic sections for the Society.—Mr. J. D. H. Dickson, M.A., Fellow and Tutor, Peterhouse, Cambridge, communicated a new method of investigating relations between functions of the roots of an equation and its coefficients.—Prof. G. Forbes exhibited some of the more striking electrical experiments with Mr. Crookes's high vacua. The deflection by approach of a magnet of the molecular stream from the negative electrode formed the point of greatest interest; and in the course of the subsequent remarks Prof. Chrystal mentioned that he had investigated mathematically to a first approximation the curve which the otherwise straight stream of charged molecules would take if projected at right angles to magnetic lines of force. To the degree of approximation considered this curve was a circular arc, whose plane was perpendicular to the lines of magnetic force. Prof. Tait communicated an additional note on Minding's theorem, which had been partly suggested by Prof. Chrystal's investigation.

Paris

Academy of Sciences, January 26.—M. Edm. Becquerel in the chair.—The following papers were read:—Influence of temperature and of elasticity on the cables of suspension bridges, by M. Resal.—On the levulosate of lime, by M. Peligot. He finds its composition very different from that attributed to it. The products of action of alkalis on levulose are those of the same substances on glucose got by saccharification of starch; and they are the more complex because of the intervention of air in the successive transformations they effect.—On the acids which arise when raw fatty acids are redistilled in a current of superheated steam, by MM. Cahours and Demarçay. Acids of the fatty series, from acetic acid to caprylic acid were obtained, and probably much higher terms were present; acids belonging to the succinic series seem also to be produced.—On variations of the force of the heart, by M. Marey. He connected the isolated heart of a tortoise in a tube-system representing the circulation, and to measure its *possible* force (ordinary experiments giving only the heart's *actual* effort), he compressed the arterial tube beyond the manometer (which was near the heart), which then rose to twice or thrice the height corresponding to functional action. The maximum effort is at commencement of systole, and it decreases towards the end. The heart has more force the fuller it is. When an obstacle increases the resistance the movements become slower and the ventricle has more time to fill, and thus acquires more force in systole.—Remarks on chlorophyll, by M. Pringsheim. A *résumé* of researches lately described to the Berlin Academy. Chlorophyll is not directly related to decomposition of carbonic acid, but plays rather a regulative *rôle* in the respiratory act of plants.—A letter from M. de Lesseps announced his arrival on the American coast (December 30), and his receptions *en route*, at Martinique, &c.—On a new voltaic condenser, by M. D'Arsonval. Studying Planté's battery, he conceived the idea of substituting liberation of a *solid* metal, zinc, for that of a *gaseous* metal, hydrogen; electrolysing a salt of zinc (the sulphate). To present more lead-surface for oxidation, he uses dust-shot, surrounding a carbon plate. A zinc plate is also inserted, and when a voltaic current passes from the carbon to the zinc the latter plate has zinc deposited on it, and the oxygen forms peroxide of lead with the lead, the sulphuric acid remaining free. With a small couple containing only 1 kg. dust-shot he worked a Deprez motor four hours. A layer of mercury does still better than the zinc plate. The maximum electromotive force was 2·1 volts.—Use of sulphide of carbon for destruction of phylloxera, by M. Boiteau.—On the resistance of phylloxera to low temperatures, by M. Girard.—On functions of two variables with three or four pairs of periods, by M. Appell.—On doubly periodic functions of the second species, by M. Mittag-Leffler.—On the determination of numerical equations having a given number of imaginary roots, by M. Laguerre.—On photography of the infra-red portion of the solar spectrum, by Capt. Abney.—On the density of chlorine at high temperatures, by M. Crafts. Improving MM. Meyer's apparatus, he finds, with them, that at the highest temperature of the Pernot furnace, iodine diminishes in density, and increases in volume in the proportion of about 1 : 1·5 compared with air. The proportion for bromine is about 1 : 1·2; but for chlorine he has not found more increase of volume than a few hundredths, in place of the 50 per cent. of MM. Meyer.—On some facts relative to urinary secretion, by MM. Richet and Moutard-Martin. Diuretic medicaments should be sought chiefly among substances found normally in the urine (as urea, chlorides, phosphates, &c.; they become diuretic, whenever in excess of the normal quantity), or substances which pass easily into the urine (as sugar). Distilled water injected into the veins diminishes or arrests urinary secretion.—On lesions of the kidney and the bladder in rapid poisoning by Cantharidine, by M. Cornil.—Researches on the mode of formation of otocephalian monsters, by M. Dareste.—On the structure, development, and pathological signification of tubercle, by MM. Kiener and Poulet.—On the crateriform disposition of solar faculæ and granulations, by Dom Lamey. A reply to M. Janssen.—On the temperature of the subterranean waters of Paris during December, 1879. The temperature of the drainage was always considerably above zero; this affected the freezing of the Seine considerably, near where the sewage entered the river, and the author suggests directing the waters along the quays a few days in extreme cold. Some farmers in the Gennevilliers plain had the sewage applied in December to freeing their fields of snow.

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