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

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

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

II.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

[2] Lord Kelvin (Sir W. Thomson), "Collected Papers," vol. iii., 1890, pp. 436-472.

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

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

## *UNIVERSITY AND EDUCATIONAL INTELLIGENCE.*

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

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

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

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

## *SCIENTIFIC SERIALS.*

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

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

## *SOCIETIES AND ACADEMIES.*

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

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

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

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

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