THURSDAY, MARCH 25, 1897.

GALOISIAN ALGEBRA.[1]

Lehrbuch der Algebra. Von Heinrich Weber. Zweiter Band. Pp. xvi + 796. (Braunschweig: Vieweg und Sohn, 1896.)

IN one of Mrs. Barbauld's stories a domestic fairy, with one touch of her wand, transforms a tangled heap of parti-coloured silk into an orderly array of neatly wound skeins. Not unlike this is the effect of group-theory upon mathematical analysis; and it has been truly said that, for some time to come, the progress of analysis will be approximately estimated by the advance in our knowledge of the constitution of groups.

We have, therefore, good reason to be grateful to Prof. Weber for the very clear and masterly exposition of group-theory which is contained in the first three books of his second volume. It may be that we have read it at the psychological moment; in any case, it seems to us the clearest and most interesting account of the subject that we have seen.

In the spirit of Cayley's *dictum* that a group is defined by the laws of combination of its symbols, the author begins by a perfectly abstract definition of a group, and develops the theory of its normal and other divisors, the composition of its parts, and a series of important theorems on the decomposition of a group and its associated indices. The first chapter concludes with a further and more general discussion of metacyclic groups, already introduced in Vol. i.

Chapter ii., on Abelian groups, is substantially a revised and improved version of the author's well-known memoir in the *Acta Mathematica.* The discussion of the characters of an Abelian group, in particular, seems to us much more easy to understand than the corresponding part of the original memoir. The most important results in this chapter are the existence of a basis; the isomorphism of groups with the same invariants; the fact that to every divisor of an Abelian group, of index j, corresponds a set of exactly j characters, which for all elements of the divisor have the common value 1, while for every other element of the group at least one of the characters has a value different from unity; and, finally, that every divisor is associated with a definite reciprocal group whose degree is equal to the index of the divisor.

The next chapter, which again reproduces, in great measure, Prof. Weber's original memoir, contains a complete discussion of the groups of a cyclotomic corpus. It is impossible to give a brief analysis of this very important chapter: it must suffice to say that a definite algorithm is given for determining all cyclotomic corpora which correspond to a given set of invariants, and for constructing the associated cyclotomic periods. Chapter iv. contains applications of the general theory to cubic and biquadratic corpora, and a proof that all Abelian corpora of the third and fourth degrees are cyclotomic. In other words, the roots of an Abelian cubic or biquadratic equation with rational integral coefficients may always be expressed as rational and integral functions of roots of unity. This is a special case of a very remarkable theorem of Kronecker's, first proved by Prof. Weber, and demonstrated later on in the present work.

Chapter v. contains a further discussion of groups in general, and brings the reader fairly abreast of contemporary research. The very real advance which has been made in this subject in recent years may be said to date from the publication of Sylow's fundamental theorem that if n is the degree of a group and p^a a power of a prime which divides n, the group contains a divisor of degree p^a. A very simple inductive proof (after Frobenius) is given in this chapter; and this is followed by a series of propositions, hardly less important, and more or less depending upon it. Then we have a remarkable theorem, due to Frobenius, that if the degree of a group is not divisible by a square, it must be metacyclic; and the other one, also discovered by Frobenius, that every group whose degree is $p^a q$, where p and q are different primes, is metacyclic. These theorems dispose of most groups whose degrees do not exceed 100: the rest are separately discussed in § 34, where references are given to the recent papers of Cole, Hölder, and Moore. It may be remarked that English mathematicians are devoting a good deal of attention to group-theory at present: reference might well have been made to the work of Askwith and Burnside. The last article of this chapter contains a proof of the theorem that the permutation-group of n letters contains no transitive and primitive divisor of index not exceeding n, except the alternate group of index 2; a further exception being made for $n=4$, and for $n=6$ respectively. Although the proof given is, of course, perfectly sound, it does not seem the truly ideal one; and it may very well happen that in this, as in other similar cases, a more appropriate demonstration will be ultimately discovered.

Book II. deals with linear groups, and in particular with the polyhedral and congruence groups with which the researches of Klein have made us so familiar. The polyhedral groups are exhibited in an analytical form, which makes it comparatively easy to discern their subgroups; the proof that, besides the polyhedral groups, there are no other finite groups of the same type is after the manner of Gordon, and is remarkably simple in character. The decomposition of congruential groups (to a prime modulus) is effected very easily with the help of Galoisian imaginaries. The whole book may be profitably compared with the corresponding part of Klein's "Modulfunctionen," which, of course, traverses much the same ground.

Book III. contains various interesting applications of group-theory. The first chapter is on metacyclic equations, especially those of degree p^a, where p is a prime. It is shown that the Galoisian group of a primitive irreducible metacyclic equation of degree p^a is isomorphic with a linear congruence group (mod. p) of a variables; this group is compounded of a metacyclic group, isomorphous with

$$z'_i \equiv z_i + a_i \ (\text{mod. } p),$$

and a *homogeneous* congruence group. Thus the problem of finding all such metacyclic equations is reduced to that of finding all the metacyclic divisors of the homogeneous congruence group. With the help of these

[1] The first volume of this work was reviewed in NATURE of November 12, 1896 (pp. 25–28).

results it is shown that all equations of the ninth degree with a linear congruence group are metacyclic, and a complete account is given of metacyclic equations of the degrees 4 and 8 respectively.

The next two chapters illustrate the power of group-theory in dealing with a certain class of problems in analytical geometry. The configuration of the inflexional tangents of a plane cubic, and the much more complicated configuration of the twenty-eight double tangents of a quartic, are here reduced to the scheme of a group. The advantage thus gained is twofold: a clear comprehension of the structure of the configuration, and the appropriate engine for attacking the algebraic problems which the geometry suggests. Thus (p. 389) the fact that the Galoisian group of the equation of the twenty-eight double tangents of a quartic is simple and doubly transitive, is intimately connected with the existence of Steiner's sets of six associated pairs of double tangents; and the structure of the group shows the exact nature of the algebraical problem which consists in the separate determination of these sets of lines.

Chapter xiii. deals with the solution of the general quintic equation. It is now well known that the general quintic cannot be solved by radicals, and that it has no resolvent of lower degree than the sixth. By the solution of the quintic is now understood either the expression of its roots by means of transcendental functions, such as elliptic or modular functions; or else the expression of its roots in terms of a definite algebraical irrationality, such as that furnished by the icosahedral equation. The chapter before us is chiefly concerned with the second method; it is shown that the equation

$$y^5 + 5ay^2 + 5by + c = 0$$

where a, b, c are any constants whatever, may be identified with one of the principal resolvents (Hauptresolventen) of the icosahedral equation of the sixtieth degree, usually written in the form

$$T^2 - zf^5 = 0.$$

The process of identification requires the determination of z and of two other auxiliary parameters λ, μ, which fix the particular resolvent to be chosen. If Δ is the discriminant of the given quintic, the three auxiliary parameters are expressible as rational functions of a, b, c and $\sqrt{5\Delta}$. Ultimately, then, the roots depend in a quite simple way upon those of the icosahedral equation; this latter, although of a high degree, is very convenient of application, because its Galoisian group is known, and its roots are algebraical functions of a single parameter (z). Moreover, one of its roots may be simply expressed by means of the hypergeometric series (see p. 432). From this point of view then, if the solution of numerical quintics were a matter of practical importance, we should construct a single-entry table of the values of the icosahedral irrationality for different values of z, and then make use, in each particular case, of the formulæ of identification above referred to.

Chapters xiv. and xv. contain a theory of ternary groups of substitutions, and deal in particular with a group isomorphous with the G_{168}, which may be otherwise represented as a congruence-group, mod. 7. This admits of a very interesting application to a special class of equations of the seventh order, analogous to the use of the icosahedral equation in solving the quintic.

The fourth, and concluding, Book is on algebraical numbers; and to those whose predilections are arithmetical this will probably prove the most interesting of all. When Kummer generalised Gauss's theory of complex integers by introducing complex roots of unity of any order, he was at first baffled by the perplexing fact that in certain cases complex integers presented themselves which were incapable of resolution into factors, and yet did not possess all the essential qualities of prime factors; thus, for instance, one and the same number might be expressible both as $\alpha\beta$ and as $\gamma\delta$, where α and β were integers essentially distinct from γ and δ, and yet α, β, γ, δ were all indecomposible. By a stroke of unsurpassed genius, Kummer devised a theory of ideal primes, which at once removed the difficulty, and enlarged the province of arithmetic indefinitely. The divisibility of one real complex integer by another may be expressed by a series of linear congruences: Kummer succeeded in showing that, associated with every cyclotomic corpus, there are certain sets of congruential conditions which are precisely analogous in the general theory to divisibility by different primes in ordinary rational arithmetic. The satisfaction of one of these sets of congruences *may* denote divisibility by an actual (complex) prime; but whether this is so or not, the nature of the limitation thus imposed is just the same, and so, when the actual prime divisor does not exist, we say that the satisfaction of the congruential conditions expresses the existence of an *ideal* prime factor. As an example of how ordinary divisibility may be expressed by congruential conditions, we may take

$$ax + by \equiv 0,\ bx - ay \equiv 0\ (\text{mod. } a^2 + b^2)$$

which, if satisfied simultaneously, are equivalent to the divisibility of $x + yi$ by $a + bi$. Here, of course, when the congruences are satisfied, the complex factor $a + bi$ actually exists; but the congruences may be discussed, and their arithmetical significance developed, quite independently of this fact.

Kummer actually succeeded in showing how to construct, for any given cyclotomic corpus, the congruential conditions associated with the actual or ideal primes contained in it; but when his theory is extended to general algebraic corpora, it becomes impracticable to carry out the investigation precisely on Kummer's lines. The fundamental idea remains the same; and by an appropriate modification at the outset, Dedekind and Kronecker each succeeded in constructing an arithmetical theory capable of application to any corpus of algebraical integers whatever.

Their methods are not so different as at first sigh they may appear; this may be shown by an example which illustrates a fundamental point of the theory. Suppose that α and β are two ordinary rational integers; then the linear form $x\alpha + y\beta$, in which x, y assume all rational integral values, comprises a certain set of rational integers, and these are, in fact, the multiples of the greatest common measure of α and β. Thus, since a rational integer is given when all its multiples are given, we may say that the greatest common measure of α and β is represented by the linear form $x\alpha + y\beta$, or by the series of integers comprised in that form. Now this notion may be extended to the case when α and β are any two algebraical integers belonging to the same corpus; and the extension may be made in two ways. In Dedekind's theory x and y, as before, stand for rational integers, and our attention is directed not so much to the form $x\alpha + y\beta$ as to the series of numbers it represents. This series is called an ideal, and denoted by $[\alpha, \beta]$; so far as α and β are concerned, it is found to possess properties precisely analogous to those of the greatest common measure. Kronecker, on the other hand, keeps the form $x\alpha + y\beta$ explicitly, using x, y as mere symbols, or umbræ; and the highest common divisor of α and β is defined as follows. The norm of $x\alpha + y\beta$ is a rational homogeneous form in x, y which is the product of a rational integer and a primitive form F; by the highest common divisor of α and β we mean $(x\alpha + y\beta)/F$. This definition has, of course, to be subsequently justified.

In a certain sense, then, the difference between the two methods is merely one of symbolic; but as in other similar cases (*e.g.* the methods of Cartesian and of homogeneous coordinates), it sometimes happens that propositions which are easily proved by the one are difficult for the other, and *vice versa*. Kronecker's theory was not worked out in detail in his famous "Festschrift"; Prof. Weber has now made it easily intelligible by adopting it, with some modification, as the basis of his exposition. Simplicity is gained by omitting primitive forms, such as F above, in the expression for divisors; and by means of a few new terms, such as "functional," the discussion is made at once concise and clear.

It should be added that the reader will find in this book not only a thorough account of the elements of the subject from Kronecker's point of view, but a guide to its most recent developments. Thus, for instance, it contains Minkowski's theorem on the minimum values of quadratic forms, with important applications to minimum representatives of ideal classes; and a summary of Hensel's very important investigations, by which it becomes possible to give an *explicit* representation of the prime ideals (or functionals) which belong to a given corpus.

Chapter xx., on quadratic corpora, shows the relation of Gauss's theory of quadratic forms to the general theory. Chapters xxi.-xxiv. are devoted mainly to the proof of Kronecker's theorem that all Abelian numerical corpora are cyclotomic; in other words, that the roots of *all* Abelian equations with rational integral coefficients are rational functions of roots of unity. The proof of this involves a long series of propositions, many of which are extremely valuable in themselves; we may instance the determination of the number of classes belonging to a given corpus, and the corollary that in every algebraical corpus there are an infinite number of prime ideals of the first degree. Perhaps the proof of Kronecker's theorem may some day be attained by a less laborious route; meanwhile it is a remarkable example of those arithmetical truths which are easily stated and easily understood, but, as yet, require for their demonstration an elaborate mathematical apparatus.

Prof. Weber's concluding chapter (xxv.), on transcendental numbers, contains a proof of the transcendence of e and π, and forms an elegant *coronis* for a work which is so important and so original that it is, to a great extent, above the range of ordinary criticism. As an introduction to, and exposition of, the theory of rational algebra and its arithmetical applications, it is simply invaluable. A student of real capacity, familiar with the technique of elementary algebra, may, by reading this work, together with Dedekind's wonderful tracts ("Ueber Stetigkeit," &c., and "Was sind u. was sollen die Zahlen?") and the last two editions of Dirichlet's "Zahlentheorie," equip himself for exploration in that strange unearthly region of arithmetic which attracts some sedentary spirits in much the same way as Arctic travel charms a Franklin or a Nansen. And even though he may not be one of the few who make discoveries of real importance, he will at least be able to appreciate intelligently the work that has been done, and the progress that has been made in developing the most abstract part of the only science that deserves to be called exact.

Gratitude has been defined by some practical cynic as the expectation of benefits to come: we must plead guilty to some such feeling on reading Prof. Weber's promise of a sequel, which is to deal with applications of the theory of algebraical numbers to the theory of elliptic functions; an application already partially carried out in his "Elliptische Functionen und algebraische Zahlen." And we cannot help remembering that, in conjunction with Prof. Dedekind, Prof. Weber has laid the foundations of a thoroughly arithmetical treatment of algebraic functions of one variable, in which alone (in our opinion) will be found a complete justification of the results to which Riemann was led by his geometrical method. Is it too much to hope that Prof. Weber may sometime be willing to develop these principles into a treatise on algebraical and Abelian functions? G. B. M.

THE WORSHIP OF TREES.

The Sacred Tree; or, the Tree in Religion and Myth. By Mrs. J. H. Philpot. Pp. xvi + 179. (London: Macmillan and Co., Ltd., 1897.)

THE further we are able to penetrate the mists which hang over the early history of mankind, the more sure we become that the primeval ancestors of our race regarded certain trees with veneration and awe; and it seems quite possible that in the earliest times the tree was a symbol of a supernatural and almighty power, which we might describe by the word "god." We shall not attempt to express in years the amount of the time which must have passed since tree worship began; but it will be sufficient, in the course of this short notice, to give a few proofs of its existence in the times which antedate the literature and history of all countries except those of Egypt and Southern Babylonia.

The study of the tree in its relation to religion and myth has occupied the minds of some of our best anthropologists, and though we are inclined to think that presently certain people will find the tree in every ancient piece of work and symbol—just as some investigators find the Christian cross everywhere, and others find the lotus in every ornament—still there is no doubt that nearly every nation belonging to the ancient civilised world has connected trees with its objects of veneration; and many folk have openly admitted that they regarded them as holy things, and that, in consequence, they have performed sacred rites and ceremonies beneath and near them. Many interesting details of the subject have been collected by such indefatigable investigators as Prof. E. B. Tylor, Mr. Frazer, and the late Prof. Robertson Smith; but, as far as we remember, no one before Mrs. Philpot has taken the pains to reduce the commoner facts to a simple straightforward narrative such as she gives in the volume before us. Here we have in nine chapters a brief sketch of tree worship, which begins in times almost prehistoric, when the suppliant knelt in terror before the solitary tree or in the forest, and ends with the Christmas-tree round which children and adults gather joyfully.

To illustrate her points Mrs. Philpot introduces several well-chosen drawings, and a somewhat meagre index ends the book. It is evident that Mrs. Philpot's work is intended for all such as have not made a special study of tree-lore, and to them her little treatise will be of the greatest value; for, apart from the general accuracy of her facts, her story is told with a directness which, to say the least of it, is time-saving. Her references are, however, either too many or too few; personally we should have liked them to be increased in number, for when a reader likes a book, and is told in it where to go for further information, he sometimes goes, and thus knowledge is spread, and more people are induced to take an interest in that particular subject. On certain points, too, Mrs. Philpot might have given us more information with little increased labour. Thus, in speaking of tree worship in Babylonia (p. 7), we might with advantage have been told that Rim-Sin, a king of Babylonia about B.C. 2300, calls himself "magician of the holy tree of Eridu," and also that a cuneiform inscription actually describes this tree "with its root of crystal which stretcheth to the abyss." On p. 10, the "sacred tree of Heliopolis," of which Mrs. Philpot speaks, is, of course, the famous Persea tree near which the Cat (*i.e.* the Sun) slew the serpent of darkness; both Cat and Tree are depicted in the vignette which accompanies the seventeenth chapter of the "Book of the Dead." In the same city, too, flourished the famous olive tree which is mentioned in the text of the pyramid of Unàs (line 70), inscribed about B.C. 3500. The Tamarisk tree (*Aser*), which is mentioned in the forty-second chapter, and the Cedar tree, which plays such an important part in the "Tale of the Two Brothers," should also have been noticed. In some cases a little more information might well have been given to the reader. Thus, the Arabs believed that the Tûbâ tree (see p. 132) was specially created by God along with the Throne, and the Garden of Eden, and Adam; this statement is important, for it shows that the Muhammedans could not imagine Paradise without a tree.

The account of Alexander's visit to the trees of the Sun and Moon in India, not Persia, should have been taken from Alexander's letter to Aristotle as given in Pseudo-Callisthenes (ed. Müller, Book iii.), for the Persian translation, or rather version, modifies a great deal of it, and omits many important points. On the great trees of India and Africa the histories of Masûdî (ii. 81-83) and Ibn-Batuta (iv. 391 f.)—both available in good French translations—might have been consulted, and Mrs. Philpot would have derived scores of valuable hints about trees and their worship from Yule's edition of "Ser Marco Polo," vol. i. (2nd ed.). The four crossbars of the Tet-pillar (p. 117) are in reality four pillars, of which only the tops are seen, and these represent the four cardinal points; the late Mr. O'Neill's "Night of the Gods" contains many facts relating to the universe-tree or pillar. The pillar which joins the two paradises (p. 132) is not called "strength of the Hill of Sion," but "foundation (*mĕkhôn*) of the Hill of Sion." Among proofs of the beliefs in the existence of a "tree of life" at a very early period may be mentioned one which occurs in the text of the pyramid of Pepi I., where we read that the deceased goes to the great lake round which the gods sit, and that they give him to eat of the tree of life upon which they themselves do live; now these words were inscribed about B.C. 3500, and it is more than probable that they were first written many, many centuries before that date.

We do not call attention to these facts from any wish to find fault, but only to indicate the sources whence Mrs. Philpot may derive additional information when a second edition of her book is called for. We believe that her book will be read with pleasure by many, but it would greatly help the general reader to give him definite facts and figures which he could remember and think upon after he has closed the book.

OUR BOOK SHELF.

Relics of Primeval Life. By Sir J. William Dawson, K.C.M.G., F.R.S. Pp. xiv + 336. (London: Hodder and Stoughton, 1897.)

For more than thirty-five years *Eozoon Canadense* has been before geologists, and the evidence brought forward in support of its organic nature, and against it, has been sufficient to enable people competent to judge the question to arrive at a firm conclusion one way or the other. The case for Eozoon as a Laurentian fossil is stated by Sir William Dawson in this volume, and the observation of similar characteristics in decidedly mineral structures is either ingeniously explained, or the resemblance is declared to be illusory. The work represents the substance of a course of lectures on Pre-Cambrian fossils, delivered in the Lowell Institute, Boston, and will be read as much for the account it contains of early animal life, as for the debatable matters with which it deals.

The True Grasses. By Eduard Hackel. Translated from "Die Natürlichen Pflanzenfamilien" by F. Lamson-Scribner and Effie A. Southworth. Pp. 228. 8vo, with 110 illustrations in the text. (Westminster: Archibald Constable and Co., 1896.)

This appears to be a very good translation of a work which does not materially differ from Bentham and Hooker's "Genera Plantarum," except that the diagnoses are much briefer, though, on the other hand, they are supplemented by some figures which, by the way, are printed much too black. What part Effie Southworth took in the translation is not apparent, for the preface is signed by F. Lamson-Scribner, dating from the University of Tennessee, without any mention of the former. In fact, the book was first published in America. It is important to state that some botanical knowledge is necessary to enable a person to use the book, and also that, with the exception of the cereals and a few others only the genera are dealt with. Of these there are upwards of 300, and a rough estimate of the total number of species in the world puts them at 3000. Prof. Hackel is a well-known and accepted authority on this difficult family, so that the translation will be welcome to those botanists who are not familiar with either Latin or German. The introductory chapter on the structure, morphology and physiology of grasses enhances the value of this little book.

It may be of interest to add, in this connection, that the grasses of British India, described in Sir Joseph Hooker's voluminous "Flora," just completed, number 850 species belonging to about 150 genera!

W. B. H.

The New Poultry Guide for British Farmers and Others. By Kinard B. Baghot-De la Bere. Pp. 65. (London: Seeley and Co., Ltd., 1897.)

THIS book is addressed to small landowners and tenant farmers of Great Britain. It is a concise and practical guide to the selection and keeping of poultry for profit. Written by one who has had a wide experience, the book should appeal forcibly to the distressful agriculturist, and make him start a poultry farm at once.

LETTERS TO THE EDITOR.

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

Liquefaction of Air by Self-intensive Refrigeration.

FROM a recently published paper by Dr. Carl Linde, on the above subject, it appears that in his most successful attempt without the use of auxiliary refrigeration, he was able, with a copper-tube apparatus weighing 132 lbs., to liquefy air in two hours, with an average higher pressure of 190 atmospheres.

It will be of interest to those who have followed this subject to hear of the latest performance, which constitutes a great advance on the above results; the weight of the copper coil having been reduced to less than one-sixth, the time required for liquefaction to less than one-fourth, and the pressure of the compressed air to less than one-half.

An apparatus which I designed on an improved plan, and which was completed in May 1896, was exhibited at work at the conversazione of the Royal Dublin Society held on the 10th inst.; and, the liquid being easily removable as produced, it supplied the material for repeated demonstrations during the evening, with the usual experiments.

Air at an average pressure of 87 atmospheres was supplied by a compressor lent by Messrs. Arthur Guinness, Son, and Co., which had been formerly used for compressing carbonic acid gas; and the compressed air was carried through 80 feet of copper pipe to the room in which the apparatus worked. No auxiliary cooling by carbonic acid or other agents was used to reduce the temperature of the compressed air before or after it reached the apparatus.

The copper tube in the exchanger, weighing only 20 lbs., was disposed in a special arrangement of coils, so that the temperature was exchanged over a range of 202° C. within $1\frac{1}{2}$ of a degree, the compressed air entering at + 10° C., passing through the liquid state at − 192° C., and issuing a few seconds later at + 8·6° C.

When a start was made with the apparatus at atmospheric temperature, the jet of liquid air was clearly seen in twenty-five minutes, and the liquid was collecting in the receiver in thirty-three minutes from the start. When the apparatus was cooled down by continuous working, the liquid began to collect again in two minutes after emptying the receiver, and accumulated at a good rate: the exact quantities of liquid and air for a given time have yet to be measured.

The receiver is a glass vessel protected by a vacuum of the kind invented by Mr. Crookes, first applied to refrigeration work by M. Cailletet, of Paris, and improved and popularised by Prof. Dewar. It is further protected by a special glass attachment fitted in such a way that the vacuum vessel can be readily removed without any risk of fracturing it by movement in contact with rubber hardened by cold to the rigidity of stone, and can be quickly replaced without interfering with the effective action of the apparatus.

The apparatus has been very strongly and neatly made by Brin's Oxygen Company, of Westminster, and tested to a very high pressure. It should be mentioned that in the almost impossible event of a joint giving way, no one can be hurt, since the high-pressure air exists only in the form of a thin column or thread with very small admission-passages. The harmlessness of a burst under these conditions has been practically demonstrated with a joint constructed in such a way as to burst inside a similar construction at 120 atmospheres, when the effect proved to be quite as mild as had been anticipated, and entirely harmless—a mere blowing-off.

This is the only apparatus existing in the United Kingdom which liquefies air without auxiliary refrigerating agents.

March 13. W. HAMPSON.

Patterns produced by Charged Conductors on Sensitive Plates.

IN your issue of January 21, 1897, Mr. James I'Anson publishes some coin photographs showing the effect of the brush discharge around the edge of the coins, and around the portions in high relief, and asks if any similar results have been obtained by others.

In the *Physical Review* (vol. ii. p. 59, 1893) is an article on electric photography, in which are published some similar photographs made by me in 1892 by exactly the same method described by Mr. I'Anson. The same method is also described by Prof. F. J. Smith, whose "Inductoscript" should be by this time well known in England. The rays from the discharge around the edge of the coin are plainly shown in one of my photographs in the *Physical Review*, and are commented upon in the article.

I also gave a photograph made by the same process when the coin was insulated from the photographic plate by a sheet of mica, and mentioned others made with the coin insulated from the plate by shellac, paraffin, and gutta-percha, which would seem to disprove Mr. I'Anson's theory that the brushes are due to electrified streams of air coming in contact with the sensitised plate.

During the past year, I have repeated these experiments with both the coin and the photographic plate carefully insulated and placed between the plates of a condenser attached to the discharging knobs of a large induction coil. I have made in this way photographs of coins, and other conductors, imbedded in the centre of a block of paraffin two centimetres thick, under which circumstances they could not send off streams of electrified air.

I have also repeated in this way some of the X-ray shadow effects by placing objects between the condenser plates and the photographic plate, to intercept the waves sent off from the condenser plates themselves. A good conductor placed near the photographic plate will regularly be photographed more strongly than the condenser plates, even though it be only one thickness of gold-leaf on glass; but if placed several centimetres from the photographic plate, and near one of the condenser plates, it may cast a shadow on the photographic plate. An insulator placed upon the photographic plate usually casts a shadow upon it, but in some cases insulators of high specific inductive capacity seemed more transparent than the air to the waves sent off from the condenser plates.

Since the oscillations in such a condenser field must correspond very closely in character with longitudinal waves in the ether, it seems probable that if X-rays are longitudinal ether waves, their wave-length must be very short; as, otherwise, they would induce waves in conductors similar to those induced in an alternating condenser field.

I enclose a photograph of two coins placed side by side on a sheet of mica which was laid upon the photographic plate. The whole was placed in a light-tight box, and inserted between the condenser plates, from which it was carefully insulated by large panes of heavy plate-glass. The condenser plates were 4·5 cm. apart, and a 5 cm. spark was passed between the discharging knobs of the coil for two minutes, after which the plate was taken out and developed in the usual manner. It was found later that an exposure of a few seconds gave equally good results.

This photograph was selected for comparison with those of Mr. I'Anson because the rays are plainly shown, while the shadow of the mica sheet, which was between the coins and the photographic plate, can also be plainly seen. It will be noticed that the rays are most numerous between the coins.

FERNANDO SANFORD.

Stanford University. Cal., February 19.

[The photograph referred to by Mr. Sanford is similar to one which illustrated Mr. I'Anson's letter (p. 270), the chief difference being that a greater number of rays are shown in the space separating the two coins.—ED. NATURE.]

Laboratory Use of Acetylene.

IN your issue of September 3, 1896, appeared a short letter stating that acetylene was in use in our laboratory for blowpipe work, and further stating that we hoped to introduce the gas on to the benches. From one or two inquiries received since then, it would seem that the fact of our now having succeeded in doing this will be of interest, as, indeed, it should be to any one possessing or contemplating the erection of a laboratory in the country where ordinary gas is costly or not obtainable. We use an ordinary Bunsen of special dimensions, the aperture of the jet being very small, and the tube (also of small diameter) is provided with a cap to protect the burner from dust when not in use. The generator is a modified form of one of those at present in the market, and gives between seven and eight inches water pressure. With six inches pressure a perfectly non-sooty flame of good size can be obtained, and a "quarter Bunsen flame" under as little as three and a half inches. If turned lower than this, the flame becomes luminous, the draught becoming insufficient. The flame is steady, noiseless, and, unless turned too low, evinces no tendency to strike down. The consumption of gas averages one cubic foot per burner per hour. The flame possesses, of course, great heating power, one volume of acetylene being for practical purposes nearly twice as effective as one volume of ordinary gas. This means an immense saving of time in all heating operations, and in many cases, such as small fusions and simple glass-working operations, we are able altogether to dispense with the blow-pipe; the burner alone supplying quite sufficient heat. Our installation has only just come into use, but, so far, has given us no trouble. We have used an acetylene blow-pipe for nearly a year, and have had no difficulties. The cocks and general fittings should be thoroughly good; any one who has not gone into the matter will be surprised to find what an indifferent article, as regards leakage, is the average gas-cock. It will be found that the cocks tend to work stiff, probably on account of the absorption of the acetylene by the lubricant, and it is much to be desired that the question of the most suitable lubricant should be investigated.

The Laboratory, Felsted School, Essex. A. E. MUNBY.

Immunity from Snake-bites.

IN case any of your readers may be working on the subject suggested by Mr. Dawson Williams in NATURE, March 4, page 415, that mosquitoes may be the carriers of pathogenic microbes, I send you the following.

In a town in the interior of Asia Minor, where I resided some years, and where malarial fever was at all times very common, I frequently noticed that when the wind blew from the direction of swamps in the vicinity, bringing numbers of mosquitoes, there would be an increase in the number of men, both native and European, down with fever *about a week later*. Had the wind brought the malaria, or dust containing fever germs from the swamps, the increase in number of fever cases might have been expected within two or three days; but as generally a week elapsed, some less direct cause was to be sought, and I always thought the mosquitoes were the culprits.

That mosquitoes do more than inject a specific toxin may be inferred from a fact I have noticed—that people who have been living in the interior of this country and have become inured to the bites of the insects from the swamps, on coming to this town, where sewerage and dirt of all descriptions abound, are painfully conscious of the attacks of mosquitoes here, nd *vice versâ*.

Those who have suffered much from fever are generally immune from the usual pain of mosquito bites, and I have heard natives say that they have suffered so much from fever that even the mosquitoes will not bite them.

During the summer months, in certain localities in the interior, labourers are exposed to the bites and stings of tarantulas and scorpions. I have frequently seen men stung several times in the same season, and found that *invariably* they suffered less from each successive sting or bite. J. BLISS.

Smyrna, March 12.

The Stereoscopic Studies of Clouds.

SINCE 1894, I have been making stereoscopic studies of clouds with wide separation of the cameras.

Beyond the direct interest of the pictures, the method has a practical value.

(1) In the measure of the distance of clouds by photogrammeters, it is usual to mark by a pin-prick the corresponding points of the two prints. Through the vagueness of cloud outlines it is easy to err in doing this, but any error thus made is easily detected by the stereoscope.

I have recently learnt that this method has been already suggested by Mr. M. J. Amsler-Laffon, of Schaffhausen, but I do not know whether it has been previously put to a practical test.

(2) My photographs were taken by visible signal without electric connection, some of them with a base of fully five hundred yards, and the clear stereoscopic definition seems to show that in ordinary cases the expensive electric connection of the cameras may be dispensed with, without affecting the value of the plates for purposes of measurement.

19 The Boltons, S.W. JOHN TENNANT.

FAMOUS SCIENTIFIC WORKSHOPS.

I.—LORD KELVIN'S LABORATORY IN THE UNIVERSITY OF GLASGOW.

AS Lord Kelvin stated nearly twelve years ago, in an address at the opening of the Physical and Chemical Laboratories at the University College of North Wales, the establishment of scientific laboratories at universities and colleges for the experimental training of students is a comparatively recent idea. Private laboratories, no doubt, existed at a very early period. The old alchemists had places, sometimes secret retreats, meanly appointed, like the den of Wayland Smith, sometimes, when the purse and protection of a powerful patron were at their command, more luxurious quarters, in which they carried on their search for the elixir of life, and the key to the transmutation of metals.

Der in Gesellschaft von Adepten,
Sich in die schwarze Küche schloss,
Und, nach unendlichen Recepten,
Das Widrige zusammengoss.

When what was spurious and unscientific in the old alchemy had gradually sublimed away, when chemistry had grown up in its place, and the experimental study of natural philosophy had begun, the only laboratories (anatomical schools excepted), as a rule, were those in the houses of investigators, and to these admission was given by the masters only to their favourite disciples. There the work done was entirely that of research: such a thing as a course of laboratory exercises, carried on with a view to the passing of an examinational test of experimental knowledge and dexterity, was undreamed of. What a change has taken place! Now, no scheme of instruction in physics, chemistry, or biology is deemed complete which does not include an extensive course of practical work to be performed by the ordinary students; and excellent and well-appointed laboratories are provided at every institution which aims at giving university instruction in scientific subjects. This is all as it should be, were it not that the examinational test is in too many cases made a great deal too much of.

The Scottish Universities have often been criticised adversely, most frequently by men who knew little about them or the work they do, but on several memorable occasions they have led the way in scientific progress. To a resident graduate of the University of Cambridge the world owes the Newtonian Philosophy, but it was James Gregory, in the University of St. Andrews, who first taught the Newtonian doctrines in a University course; and Lord Kelvin was, we believe, the first teacher of Natural Philosophy who opened a physical laboratory to his students. The beginning was a memorable one. Soon after his appointment fifty years ago to the Glasgow Chair, Lord Kelvin was beginning his great series of researches on the Electrodynamic Qualities of Matter, and invited his students to aid him. Others hearing of the new work going on volunteered for service, and new branches of research were quickly opened out. Then began that famous experimental work which has been carried on at Glasgow through half a century, and still so actively continues.

The physical laboratory for many years was a disused wine-cellar in the old University buildings. To this was added, in course of time, the discarded Blackstone examination room, and in this modest suite of rooms the experimental work of the department was done, until the University removed twenty-six years ago to its palatial buildings at Gilmorehill.

For the most part the work done in this laboratory was of the nature of research. A good man was set to make some of the easier observations in an investigation which was in progress, and, beginning thus, he in a short time obtained very considerable skill in experimental processes by carrying out the determinations of the various physical constants which were required for the final result. For the best men this plan answered remarkably well. Their interest was excited, was kept alive by their constant intercourse with the guiding spirit of the place, and their zeal was such that, as the writer can testify, the laboratory corps, as it used to be called, has been known to divide itself into two squads—one which worked during the day, the other during the night, for weeks together, so that the work never paused.

The University of Glasgow is built somewhat after the fashion of colleges in Oxford and Cambridge, in the form of a double quadrangle, and in a style of Gothic architecture, with crow-step gables and turrets, rather common in baronial residences in Scotland.

Although the amount of space devoted to the Department of Natural Philosophy in the University is considerable, the physical laboratory, it must be confessed, suffers from the general plan adopted for the buildings. Of the convenience of the quadrangular arrangement for a college, consisting in the main of suites of rooms for students and fellows, with dining-rooms, class-rooms, &c., there can be no question; but for a *university*, in which provision must be made for great experimental departments, such as physics, chemistry, physiology, zoology, and anatomy, it is far from being well adapted. Such departments are best provided for by detached buildings, or "Institute," as they are called in Germany, if possible within the University grounds.

The adjoining figure gives a view of a part of the general working laboratory. In the foreground is a writing-table, on which stands a magnetostatic voltmeter. At that table Lord Kelvin generally sits when he is in the laboratory, and occupies himself with the consideration of results which are being obtained by the men at work in the laboratory, or with the dictation of his correspondence to his secretary.

A little to the right is a stone erection built on an independent foundation. This contains a chamber in which apparatus requiring a steady support can be suspended; and it was here that the pendulum was hung by which Messrs. George and Horace Darwin made their first attempt to determine directly the attraction of the moon on a body at the earth's surface.

Behind the writing-table is another table with vertical beams at its corners, which give it somewhat of the appearance of a "four-poster" bedstead. To these vertical beams cross-bars are attached for the support of pieces of apparatus in the manner shown in the illustration.

From "Good Words."] [*From a photograph by T. and R. Annan and Sons, Glasgow.*

FIG. 1.—View of part of the General Laboratory.

In the background are two stone pillars supporting a partition wall of the rooms above, and to these were led wires from a large battery of tray Daniell cells which, before the advent of really practical dynamos, stood in the right-hand corner of the laboratory under the staircase, and supplied the current required for the various kinds of experimental work in progress. On the left of the pillars is seen part of another four-poster, and the door of a private room, partitioned off from the main laboratory, in which special experiments, or reductions of results can be carried on without interruption.

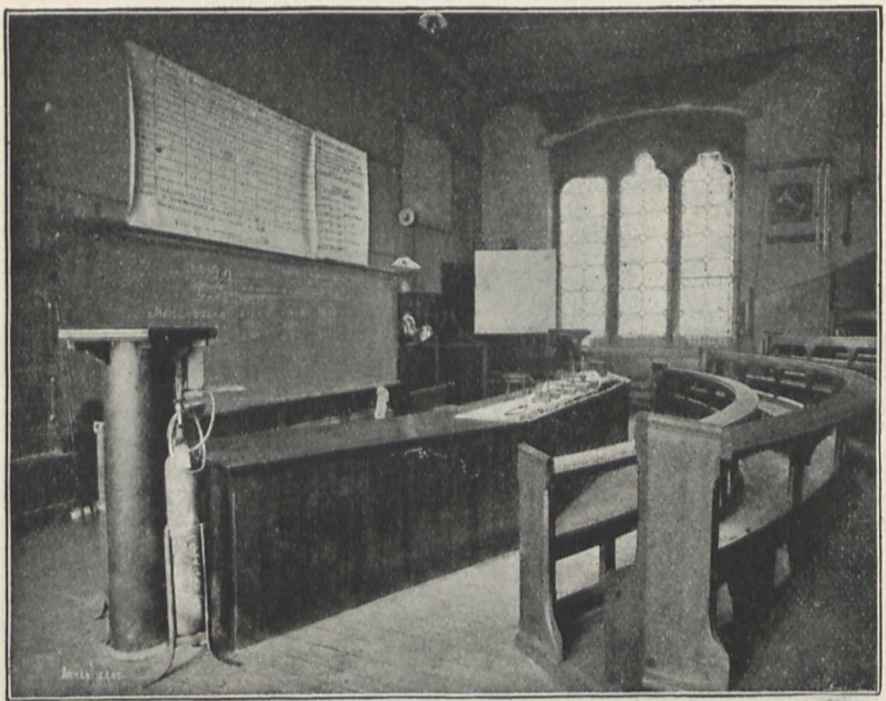
Passing up the stairway, seen at the back in the illustration, we arrive on the upper floor in a small room formed under the seats of the Lecture Theatre. Thence we can pass directly into the Lecture Theatre, or into the Apparatus Room, which is directly behind it.

The adjoining figure gives a view of the interior of the Lecture Theatre as seen from its large oriel window in the front of the building. It is a lofty apartment lighted mainly by two large windows, one the oriel just referred to, the other, seen in the picture, looking into the west quadrangle. On the sill of the latter window, which is passed each day by every student entering or leaving the room, are usually arranged a series of semi-secular experiments, in illustration of those lectures on the "Properties of Matter," which have always formed a most interesting and suggestive part of Lord Kelvin's course, and which, to every one who has heard them, have intensified the regret, felt by so many, that the second volume of Thomson and Tait's "Natural Philosophy," in which this subject was to be specially treated, is not to appear.

In one of these experiments a slab of pitch, or of shoemakers' wax in water in a glass jar, is made to confine a number of common corks below it, while in the water above the jar are placed a few lead bullets. After a month or two some of the corks are found in the water above the pitch, while the lead bullets have sunk down through the pitch to the bottom of the jar. Other corks are on their way through, and, being imbedded in the pitch, are lost to view; and of the paths followed by the corks and bullets, which have made the passage, no trace remains. All the time the pitch or wax is so brittle as to fly to pieces if thrown down on a table, or violently struck with a hammer.

To the small continuously applied forces due to the corks and bullets the pitch has behaved like a fluid; indeed, its properties have been precisely those of a highly viscous liquid. It has offered resistance to change of shape, but the resisting force has depended on the rate of progress of the change, not, as elastic resistance would, on the amount of change already accomplished. On the other hand, a piece of the same pitch melted into the form of a bell, and struck with a hammer in the ordinary way, would give out a musical note, showing that for rapidly alternating changes of shape the forces excited in the pitch are proportional to the strains produced; which indicates that the material under the latter conditions possesses the properties of a solid. Thus one and the same substance may, according to the circumstances in which it is placed, behave either as a viscous liquid or as an elastic solid.

This result is important as bearing upon the difficulty as to how the luminiferous ether, under any conceivable estimate of its density, can possess so high a degree of rigidity as to transmit the waves of transverse oscillation, which, according to the elastic solid theory of the ether, we have in light, with a velocity of 3×10^{10} centimetres per second; while the planets and the components of double or multiple stars move freely through it. The difficulty (if it is a real difficulty, and is not to be got rid of in a new view of the propagation of light based on electromagnetic theory) is not explained by this experiment; but it is reduced by it to an affair of properties of matter, by being shown to have a parallel in a phenomenon of which we have undoubted experience.



From "Good Words."] [*From a photograph by T. and R. Annan and Sons, Glasgow.*

FIG. 2.—Lecture Theatre, from front window.

Another piece of apparatus in the window is a model glacier in which a slope of wood takes the place of the sloping bed on the mountain-side, and shoemakers' wax that of ice. [See Dr. Bottomley's description in NATURE for December 18, 1879 (vol. xxi. p. 159).]

In the window also are generally displayed tubes illustrating the diffusion of liquids into one another, and the osmotic passage of a sugar solution through a diaphragm.

On the other side of the room is a large oriel window, which is partly visible in the view of the class-room table and lecture apparatus given in Fig. 3. Set up in this oriel window are two tall tubes running nearly the whole height of the room, and protected by wooden cases fitted with glass doors. One of these tubes illustrates the diffusion of sulphate of copper solution upwards into water, and the water itself in the opposite direction. The other tube shows the same thing for water and alcohol. These tubes were set up nearly a quarter of a century ago, soon after the new building was taken possession of by the University; and the original surfaces of separation, with the dates, are marked upon them. This is, perhaps, the longest experiment on diffusion that has ever been carried on; but of course it is capable of infinite duration, as an infinite time would have to elapse before the liquids in the tubes were completely mixed by this process. In his lectures Lord Kelvin is fond of accomplishing the work of an infinite time in diffusion, by reversing two or three times a closed tube in which the liquids have been originally separated by their different specific gravities.

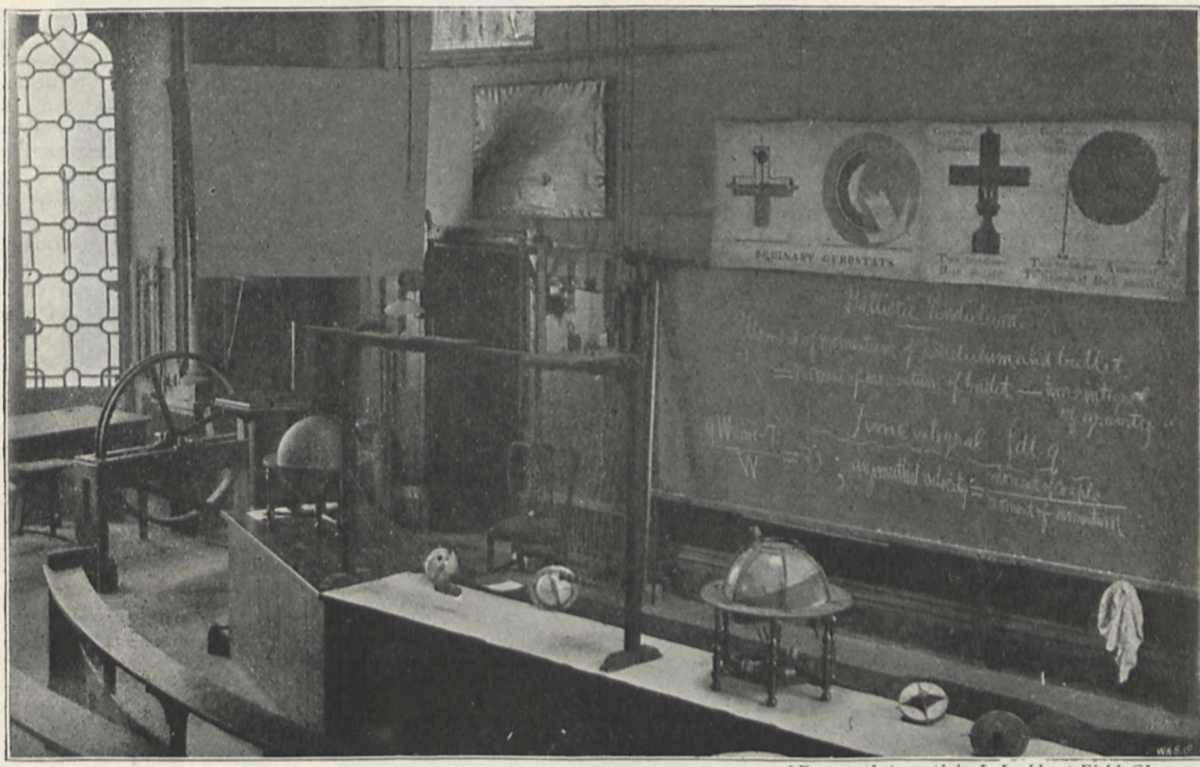
The progress of diffusion in the secular experiments is shown by the motion of specific gravity beads (small beads of glass of known mean specific gravity), which float in the liquid, and mark by their change of position the advance within the liquid of a stratum of given density. Thus the state of the liquids can be seen at a glance without either disturbing the apparatus, or setting up more or less troublesome observing instruments.

The picture shows the lecture-table with apparatus for illustrating gyrostatic action and precessional motion. On the table and to the right are ordinary gyrostats, towards the left are two hollow spheroidal gyrostats which can be filled with water, and between stands a model, well known to all Glasgow students, for illustrating the precessional motion of the earth, which arises from its gyrostatic action. One of the hollow spheroids is oblate, the other is prolate, with the same deviation from sphericity in each case. When they are filled with water and rotated, the oblate spheroid behaves like an ordinary solid gyrostat; the motion of the other is unstable, and the spin disappears immediately. On the wall are diagrams showing the construction of a gyrostat and its rotational stability under various modes of support which render it essentially unstable when there is no rotation.

Above the lecture-table is a large opening extending to the roof, so that it is possible to suspend from the roof-beams pendulums, ropes, gyrostats, and many other things of great importance for physical illustration.

The apparatus-room is a large apartment, like the other rooms of the laboratory, from eighteen to twenty feet in height. It contains two large cases of instruments occupying a large part of the floor-space, and two smaller wall-cases at the ends of the room. Here are stored the instruments used for class illustrations and research; but in the cases also are many pieces of apparatus, quaint and old-fashioned in form and ornamentation, made to a great extent from fine old mahogany. Besides these "urväter Hausrath" the cases contain several instruments of more modern design, which are far more historically interesting. One of these is the first reflecting galvanometer used by Lord Kelvin as a receiving instrument for signals through a submarine cable, the identical galvanometer, in fact, with which signals were received on board ship in the famous cable expedition of 1857, 1858; another is one of the pieces of apparatus with which Joule determined the dynamical equivalent of heat; and another is a replica of Dr. Andrews' apparatus for the investigation of the critical states of gases

In another room upstairs there used to be a complete museum of electrometers and other electrical instruments. There were to be found old attracted disc-, heterostatic, and idiostatic-electrometers, and a series of instruments illustrating the development of the quadrant form of electrometer, from the first rude model to the marvellously complete and delicate contrivance for measuring differences of electric potential, which is not one of the least of the benefits Lord Kelvin has conferred on electrical science.



[*From a photograph by J. Lockhart Field, Glasgow.*

FIG. 3.—Lecture Table, with gyrostats, precessional globe, &c., and diagrams illustrating gyrostatic action.

Beyond the lecture-room, on the side remote from the apparatus-room, is the private room of the Professor of Natural Philosophy. There Lord Kelvin, in the early years of the new University buildings, used to work a good deal. Now the private room is occupied for the most part by his nephew, Dr. J. T. Bottomley, who has had the adjoining room fitted with benches, mercury air-pumps, and other apparatus suitable for investigation of the properties of high vacua.

On the floor above the apparatus-room and lecture-room are further cases for apparatus, and a battery-room the floor of which is caulked to prevent liquid from passing through into the rooms beneath.

The Physical Department and Lord Kelvin's house at the University are lighted with electricity. Current is generated for this purpose by a dynamo driven by a gas-engine in a small room on the ground-floor adjoining the general physical laboratory. The dynamo is kept continually running, and feeds a large secondary battery in another small room above the engine-room. This battery is used to supply current for special laboratory purposes, and also to feed and regulate the incandescent lamps throughout the department.

Perhaps the first telephone line to be established in this country was that erected between the University and the instrument factory of Mr. James White, who used to be well known as Lord Kelvin's instrument-maker. This line existed alone for some time, and formed the nucleus from which sprang the Glasgow Telephone Exchange, one of the first to be established in Britain.

Before leaving the laboratory proper we must not omit to mention the secular experiments on the effect of long-continued pulling stress on the length of wires of different materials, which are being carried out under the superintendence of Dr. J. T. Bottomley in one of the lofty rooms of the University tower. There, within a case of iron extending from a short distance above the floor of one room to the bottom of the one beneath it, a distance of about sixty feet, are hung wires of gold, platinum, and palladium, two for each metal, one of the two in each case being loaded with three-fourths of the breaking weight, the other with about one-tenth of the breaking weight. The lengths of these wires are observed from time to time by Dr. Bottomley by means of a cathetometer specially constructed for the purpose (see B.A. Rep., 1879, 1886).

In the same room there used to exist, and probably exists still, a mercury pressure-gauge, consisting of a long iron tube running for about 100 feet down a well which passed from the lofty room in which the wires are suspended to another below it in the tower.

In speaking of Lord Kelvin's laboratory we ought not to confine ourselves to the University laboratory, or even to Glasgow. Lord Kelvin's house, for example, is part of his laboratory; in fact, in a very true sense his laboratory or workshop includes wherever he happens to be. In train and steamer, at home or abroad, he is ever at work; and, no matter where he may be, he is in constant communication by post and telegraph with the corps of workers at Glasgow, is in daily receipt of the results of their work, and occupied with the deduction of consequences, and the consideration of how the researches in progress may be developed and extended.

The adjoining figure is a view of Lord Kelvin's study in his house at the University. The writing-table at the window is that generally used by Lord Kelvin; that in the middle of the room is the table of his secretary. In this room he spends several hours of each day, when he is at home, carrying on his literary work with his secretary, contriving models to illustrate the arrangement of the molecules in a crystal, molecular tactics, or mechanism for imitating the functions of the luminiferous ether, or occupied with one of his numerous inventions.

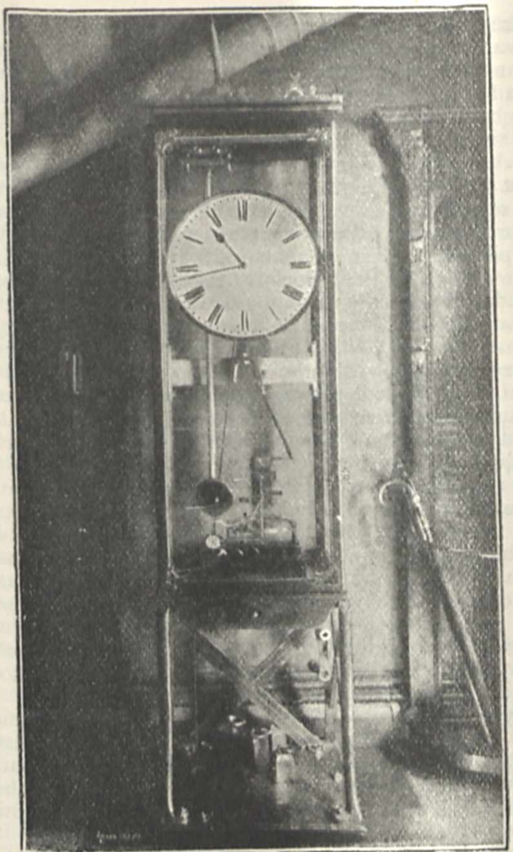
From "Good Words."] [*From a photograph by T. and R. Annan and Sons, Glasgow.*

FIG. 4.—Interior of Study in Lord Kelvin's House at the University of Glasgow.

The practical applications of physical science which Lord Kelvin has made are very varied, and they still occupy a considerable amount of his time and attention. Just outside his study, in the hall of his Glasgow house, stands a very remarkable clock which is designed to run at an almost strictly uniform rate (instead of discontinuously, like ordinary clocks and watches), and to show Greenwich mean time to a higher degree of approximation than is possible with a clock possessing any of the ordinary escapements. A full account of this clock is to be found in NATURE for January 11, 1879 (vol. xv. p. 227).

The instrument-making establishment formerly presided over by James White, and now carried on by a firm which has succeeded him, is a large factory situated in Cambridge Street, Glasgow, and in many respects may be considered a branch of Lord Kelvin's laboratory. A portion of it is shown on the next page (Fig. 6). The workshops consist of several floors, which are set apart for different departments of the work carried on. An 80-H.P. engine supplies power for the machinery, which comprehends many instruments and tools, such as lathes, &c., of precision. A large and fully-equipped standardising laboratory is provided on the ground-floor for the graduation of the standard electrical instruments which Lord Kelvin has recently placed in the hands of practical electricians.

Here his various navigational and electrical instruments are made, tested, and sent out for use; and here, when at home, he spends a part of almost every day. His usual programme is, after giving instructions regarding the correspondence of the morning to his secretary, and lecturing to his class from 9 to 10 o'clock, if it is one of his days to do so, to walk or drive into town to White's, there often to remain until time to return to the University for a midday lecture or for luncheon. In these visits to White's many scientific problems have been solved, and many others have been suggested, the solution of which, if unattainable, had to be avoided by



[From a photograph by T. and R. Annan and Sons, Glasgow. From "Good Words."]

FIG. 5.—Astronomical Clock in the Hall of Lord Kelvin's House.

material. This in its turn, owing to the invention of telephony, has had to be modified by the introduction of quantities which, neglected before, become in rapid periodic signalling of primary importance. Thus we have the complete theory of the propagation of electric waves along wires, with which we have been made familiar by the researches of Lord Kelvin himself, Heaviside, J. J. Thomson, and Hertz.

Another important part of Lord Kelvin's real laboratory used to be his yacht. For many years his commodious schooner, the *Lalla Rookh*, was put in commission early in April; and from then till the end of October, Lord Kelvin sailed the seas. Sometimes he went as far as Madeira, or up the Mediterranean, but generally he cruised between the Clyde or the Hebrides and the Solent. Wherever he was, he was busy with scientific research, and the mathematical discussion of some abstruse problem in fluid motion, carried on with notebook and pencil, alternated with a trial of some new form of sounding machine, or an observation of waves or ripples. Lord Kelvin is a thoroughly skilled and scientific navigator; in fact he is one of the most distinguished authorities, not only on matters of physical science, but also on questions of naval architecture and practical navigation.

In all the work of the Physical Laboratory the aim has ever been to render the student self-dependent and resourceful. The writer well remembers being told, not long after he entered the laboratory, that he ought to have taken to pieces a quadrant electrometer to find out what prevented it from acting properly, when all else had failed to disclose the fault in the instrument. And many others have had similar experience. It is very doubtful, indeed, if too much is not done for students in many laboratories, in the way of arranging for their individual pieces of work, and furnishing them with ready set-up and unexceptionable instruments.

But beyond everything in the laboratory at Glasgow has ever been Lord Kelvin's presence and example, and

adopting some other means of obtaining the desired result. These constant relations of practice to theory and theory to practice, which Lord Kelvin, in consequence of his great inventive activity, has had always to keep in view, have been fraught with important consequences to science.

It would be difficult to say how many of Lord Kelvin's contributions to the advancement of pure science have resulted from his keen interest in applications of science, and his knowledge of the resources and uses of mechanism; but it is certain that many of them may be credited to this account. It was the practical question of how to signal at a rate commercially successful through a submarine cable that led him to the discussion of the diffusion of electricity through a long copper conductor, separated from an external conductor by a cylindrical sheathing of insulating

From "Good Words."] [From a photograph by T. and R. Annan and Sons, Glasgow.

FIG. 6.—A part of James White's Instrument Factory.

the charm of his personal influence. Throughout his long tenure of the chair of Natural Philosophy, he has carried lightly like a flower the weight of honour which the scientific world has united to render to him. He has remained ever the same kind friend of his students, and his interest in them, old and young, and in every scientific worker, has found many quietly sympathetic modes of expression. The enthusiastic testimony to his pre-eminence as a scientific man, and to his admirable personal qualities, which was borne by the whole world at the magnificent celebration last June, will not soon be forgotten by those who had the privilege of taking part in that great ceremonial: it was an emphatic tribute to the greatness of the part which the Physical Laboratory at Glasgow has played in science during the last fifty years. A. GRAY.

JAMES JOSEPH SYLVESTER.

HE is dead, and it becomes a sad duty to give a brief account of his long life and great work.

Born in London September 3, 1814, he was the youngest but one of seven children of Abraham Joseph Sylvester. He was the last survivor. Three sisters lived for many years at Norwood, and of his three brothers two, Frederick and Joseph, lived for the most part in America, whilst George resided at Worcester.

He obtained his early education at private schools in London; thence he went to the Liverpool Institution, and in 1837 graduated at St. John's College, Cambridge, as Second Wrangler. The first five names in the Mathematical Tripos of the year are Griffin, Sylvester, Brumell, Green, Gregory. It is astonishing to think that Green, of immortal memory, has been dead for nearly fifty years! Sylvester was keenly disappointed at his failure to be senior of the year. He was always of an excitable disposition, and it is currently reported that, on hearing the result of the examination, he was much agitated. Being of the Jewish persuasion, he was unable to take his degree at Cambridge, but later he obtained a degree at the University of Dublin. On leaving Cambridge he at once commenced the long series of mathematical papers, which he was to contribute to scientific periodicals all over the world, by the publication, in vol. xi. of the *Philosophical Magazine*, of an analytical development of Fresnel's optical theory of crystals.

This was followed by some articles upon subjects of applied mathematics, and it was not until 1839 that he brought his intellect to bear upon the analysis of continuous and of discontinuous quantity, departments of pure mathematics which well-nigh monopolised his attention for the remainder of his life. He was appointed Professor of Natural Philosophy at University College, London, and later on held the post of Professor of Mathematics in the University of Virginia. He returned to England in the year 1845, and the first period of his scientific career may be said to have closed. He had published some thirty papers, and was already well known in both hemispheres as an original and imaginative man of science. The subjects dealt with comprise "Dialytic Method of Algebraical Elimination," "Sturm's Functions," "Criteria for Determining the Roots of Numerical Equations," "The Calculus of Forms" (afterwards known as the "Theory of Invariants"), "The Equation in Integers $Ax^3 + By^3 + Cz^3 = Dxyz$." The latter problem was a favourite subject of thought throughout his life, and the first problem in the theory of numbers that he attacked. The theory of invariants sprang into existence under the strong hand of Cayley, but that it emerged finally a complete work of art, for the admiration of future generations of mathematicians, was largely owing to the flashes of inspiration with which Sylvester's intellect illuminated it. The nomenclature of the theory is almost entirely due to him. The words "invariant," "covariant," "Hessian," "discriminant," "contravariant," "combinants," "commutant," "concomitant," are a few of those introduced by him at this time, which have been part of the stock-in-trade of mathematicians ever since.

A beautiful theory of the rotation of a rigid body about a fixed point, after Poinsot, should be mentioned. It is one of the few papers that he wrote on dynamics.

For ten years after his return from Virginia he was occupied with a firm of actuaries. He founded the Law Reversionary Interest Society, and also accomplished a considerable amount of mathematical research. In 1853 appeared his first important memoir in the *Philosophical Transactions* of the Royal Society, bearing the title, "On a theory of the syzygetic relations of the rational integral functions, comprising an application to the theory of Sturm's functions and that of the greatest algebraical common measure." This is a masterly exposition, covering 170 quarto pages.

In 1855 he was appointed Professor of Mathematics at the Royal Military Academy, Woolwich. This was a great relief, as the work of an actuary was manifestly unsuitable, and had indeed been most distasteful to him. He held this professorship for fifteen years. It was a time of great activity. Year by year his fame increased, and recognition by foreign academies was liberally bestowed. In addition to continual work at the theory of invariants, he laboured at some of the most difficult questions in the theory of numbers.

Cayley had reduced the problem of invariant enumeration to that of the partition of numbers. Sylvester may be said to have revolutionised this part of mathematics by giving a complete analytical solution of the problem, which was in effect to enumerate the solutions in positive integers of the indeterminate equation—

$$ax + by + cz \ldots + ld = m$$

Thereafter he attacked the similar problem connected with two such simultaneous equations (known to Euler as the Problem of the Virgins), and was partially and considerably successful. In June 1859, he delivered a series of seven lectures on compound partition in general at King's College, London. The outlines of these lectures, printed at the time for distribution amongst his audience, are now being published for the first time by the London Mathematical Society. He was assisted in the preparation of these lectures by Captain (now Sir Andrew) Noble, with whom from that time forth he was in sympathetic friendship.

The year 1864 may be regarded as the time of his greatest intellectual achievement, which caused him to be considered as one of the foremost of living mathematicians. On April 7, 1864, he read a paper before the Royal Society of London, bearing the title "Algebraical Researches, containing a disquisition on Newton's rule for the discovery of imaginary roots, and an allied rule applicable to a particular class of equations, together with a complete invariantive determination of the character of the roots of the general equation of the fifth degree, &c." In the "Arithmetica Universalis," Newton gave a rule for discovering an inferior limit to the number of imaginary roots in an equation of any degree, but without demonstration. Neither did he give any indication of the mental process by which he was led to conjecture the truth of the rule, nor did he set forth the evidence upon which it rests. For years the question of proving or disproving the rule had been a crux of the science. Euler, Waring, Maclaurin and Campbell were amongst those who sought in vain to unravel the mystery. The only step that had been gained was to show that if *any* negative terms occur in the quadratic elements involved in the statement, there must be *some* imaginary roots. This, however, was not a great step, as a slight consideration renders it apparent. Sylvester, in the paper quoted, established the validity of the rule for algebraical equations as far as the fifth degree inclusive. The method employed was that of "infinitesimal substitution," which he himself initiated, and had previously employed in an essay, "On the Theory of Forms," in the *Cambridge and Dublin Mathematical Journal*. It proceeded upon the principle that every finite linear substitution may be regarded as the result of an indefinite number of simple and separate infinitesimal variations impressed upon the variables. He also discussed the probability of the specific superior limit to the number of real roots in a superlinear equation equalling any assigned integer. This valuable memoir contained only a small instalment of the desired result. It was not till the following year—1865—that he fully established and generalised the conjectured theorem of Newton. On June 19, he communicated the substance of his discoveries to the Mathematical Society of London, Prof. de Morgan being in the chair as its first president; and on the following June 28 he gave a public lecture in King's College, London, taking as his title, "On an elementary proof and generalisation of Sir Isaac Newton's hitherto undemonstrated rule for the discovery of imaginary roots." Sylvester's fame with posterity will, perhaps, be principally associated with this great intellectual triumph. It may be observed that, subsequent to the demonstration, Dr. J. R. Young claimed to have proved Newton's rule twenty years before. Sylvester contested this assertion in a characteristic manner, and mathematicians are, I think, in agreement that he showed it to be without basis. He always wrote well and with considerable power of expression; but, perhaps, he was strongest when attempting to demolish any one who questioned or denied his claim to priority in a particular mathematical discovery. In the case in point he wrote: "It is such stuff as dreams are made of, and culminating as it does in a palpable *petitio principii* does not need a detailed refutation at the hands of the author of this lecture. It is not by such vague rhetorical processes, but by quite a different kind of mental toil, that the truths of science are won, or a way opened to the inner recesses of the reason."

When the British Association for the Advancement of Science met at Exeter, in 1869, Sylvester was the President of the Mathematical and Physical Section. Huxley had recently written in *Macmillan's Magazine*: "Mathematical training is almost purely deductive. The mathematician starts with a few simple propositions the proof of which is so obvious that they are called self-evident, and the rest of his work consists of subtle deductions from them"; and again, in the *Fortnightly Review*: "Mathematics is that study which knows nothing of observation, nothing of experiment, nothing of induction, nothing of causation." It may be safely said that any man engaged constantly in mathematical research would find no difficulty in refuting these statements to the satisfaction of any representative body of scientific men. Sylvester devoted a considerable portion of his address to the Section to contesting Huxley's statements, and put in a powerful and eloquent plea for mathematics as being a science of observation and experiment, and as affording a boundless scope for the exercise of the highest efforts of imagination and invention. Huxley, I believe, made no reply; and I think there can be no doubt that, like many other remarkable men in other branches of science, he had no conception of the real nature of the life-work of mathematicians of the high order to which Sylvester belonged. Amongst other matters in his address, he remarks upon the extraordinary longevity of the masters of mathematics. Amongst these long-lived ones he himself now takes an honourable place.

He left Woolwich (for years he occasionally wrote from his house on the Common, over the *nom de plume* "Lani Vicencis") in 1870, and for some years was without a professorship. During this time he was much interested in the problems of link-motion and conversion of motion generally. He wrote several valuable papers, and invented the skew pantigraph. The title of one of his papers of this period is characteristic—"Mode of construction and properties of a new sort of lady's fan, and on the expression of the curves generated by any given system whatever of link work under the form of an irreducible determinant."

He gave a Friday evening lecture at the Royal Institution, entitled "On Recent Discoveries in Mechanical Conversion of Motion."

His acceptance, in the year 1875, of an invitation to become the first Professor of Mathematics in the new Johns Hopkins University at Baltimore, in Maryland, may be regarded as concluding the second period of his career. He could hardly expect to further increase his reputation, which was extraordinarily high, and most of the honours that can fall to the lot of a scientific man had long been in his possession.

In Baltimore he soon founded the *American Journal of Mathematics*, and was surrounded by a knot of enthusiastic students, whose researches he was able to influence, and in some cases to entirely direct. His final investigations in the theory of algebraic invariants, various questions in diophantine analysis, the constructive theory of partitions, the theory of universal algebra, and the commencement of his researches on differential invariants, were principally the outcome of his residence in Baltimore. He was assisted, followed up, and frequently also inspired by his students in an ideal manner. Perhaps the most permanent impress he left on the path of American research was in the subject of universal algebra, the vigorous offspring of Cayley's memoir, of 1858, on matrices. He established the nomenclature of the subject and surveyed the unknown country. He showed the connection between linear transformation and quaternions, and further arrived easily at a generalisation of quaternions. Since then Taber, Metzler, and others in the New World, have made valuable additions to the theory.

In 1883 he was elected to succeed Henry J. Stephen Smith in the chair of the Savilian Professorship of Geometry at Oxford. His inaugural lecture was on the subject of differential invariants, termed by him reciprocants. This work was extensive and important, and its elaboration, with the able assistance of James Hammond, was the last valuable contribution he made to mathematics. With increasing age infirmities came upon him. He suffered from partial loss of sight and memory, and in 1892 he obtained permanent leave from his duties, and the University appointed a deputy professor.

Henceforth he lived for the most part in London, and was a familiar figure in the Athenæum Club, but he was never in good health. At intervals he would go down to Tunbridge Wells and live at the Spa Hotel, but he did no mathematical work, and his frame of mind was not happy. Early in 1896, his condition caused alarm to his friends. In August he quite suddenly became again interested in mathematical subjects, and this appeared to make him calmer and happier. On February 26, whilst working at the theory of numbers, he had a paralytic stroke and never spoke again. He died peacefully at 3.30 a.m. on Monday, March 15, 1897, at 5 Hertford Street, Mayfair.

His work was not so voluminous as that of many of his great contemporaries. It may amount to about 1250 octavo pages and about 1550 quarto pages. Its quality, however, is of a very high order, as he always preferred to labour at difficult questions; problems which for centuries have been a challenge to the human intellect had an especial attraction for him. His last thoughts were concerning the distribution of the prime numbers; the excellent paper in which he contracted Tchebycheff's limits was a source of great satisfaction to him, and shortly before he died he was hopeful of being able to prove the Goldbach-Euler conjecture that every even number can be partitioned into two primes; but in this he was not successful, although he was able to narrow the issue, and to give a more precise statement of the supposed theorem. At one time he was interested in the construction of tessellated pavements; one anallagmatic design was, through the influence of his friend Colonel Yelverton, put down in the hall of the Junior United Service Club in Charles Street, Haymarket. Some years ago it was unfortunately removed whilst the hall was undergoing repair.

His writings are flowery and eloquent. He was able to make the dullest subject bright, fresh, and interesting. His enthusiasm is evident in every line. He would get quite close up to his subject, so that everything else looked small in comparison, and for the time would think and make others think that the world contained no finer matter for contemplation. His handwriting was bad, and a trouble to his printers. His papers were finished with difficulty. No sooner was the manuscript in the editor's hands than alterations, corrections, ameliorations and generalisations would suggest themselves to his mind, and every post would carry further directions to the editors and printers. His usual custom was to send early notice of his discoveries to the Academy of Sciences in Paris. Subordinate theorems he would despatch at once to the *Educational Times*. He frequently also made announcements in the columns of NATURE. He gave so many names to mathematics that he used playfully to speak of himself as the Mathematical Adam. It has been remarked by Prof. Forsyth that he drew almost entirely upon Latin for new names, whilst Cayley as invariably drew upon Greek. In 1870 he published "The Laws of Verse," dedicating it to Matthew Arnold. The composition of sonnets, both in English and Latin, was a relaxation that he much enjoyed; these have been, and no doubt will be, criticised in other places.

He was fond of billiards, whist and chess. He liked occasionally going into the society of ladies, but was never married.

He appears in the series of portraits of Scientific Worthies for the year 1889, to the accompaniment of a sympathetic notice from the pen of Cayley. His portrait in oils, by Elmslie, was exhibited in the Royal Academy a few years ago, and now hangs in the hall of St. John's College, Cambridge. His physiognomy was striking, never failing to impress deeply at a first meeting. Latterly his appearance was venerable and patriarchal.

In this short notice justice cannot be done to his character. His temper was somewhat quick on occasions, but he never cherished angry feelings beyond a very short time; he was anxious to forget and forgive. Only those who understood him were aware that anger or displeasure was with him a transient phenomenon, and that charitableness of feeling and kindness of heart were characteristics deeply engraved upon his nature. To younger men he was sympathetic and generous.

The revival of the mathematical reputation of England, dating from the Queen's accession to the throne, is to a large degree due to his genius; and those who were present on March 19, at the simple, yet impressive ceremony at the Jewish cemetery at Dalston, must have realised that one of the giants of the Victorian era had been laid to rest. The Royal Society and the London Mathematical Society were represented at the funeral by Prof. Michael Foster, Sec.R.S., Major MacMahon, R.A., F.R.S., Prof. Forsyth, F.R.S., Prof. Elliott, F.R.S., Dr. Hobson, F.R.S., Prof. Greenhill, F.R.S., Mr. A. B. Kempe, F.R.S., and Mr. A. H. Love, F.R.S. There were also present Prof. Turner and the Sub-Warden of New College, Oxford.

P. A. MACMAHON.

NOTES

A MEETING of Presidents of various scientific societies in London was recently convened by the President and Officers of the Royal Society, to consider whether any, and if so what, steps should be taken to commemorate the sixtieth year of Her Majesty's reign. It was unanimously resolved—"That a fund to be called the Victoria Research Fund be established, to be administered by representatives of the various scientific societies, for the encouragement of research in all branches of science." The President of the Royal Society has communicated this resolution to the scientific societies, with a letter asking whether support would be given to it.

AT the recent anniversary meeting of the Royal Irish Academy, Prof. Albert von Kölliker and M. A. Michel Lévy were elected honorary members in the Section of Science.

THE subject of the Croonian Lecture to be delivered at the Royal Society on Thursday next, by Prof. C. S. Sherrington, is "The Mammalian Spinal Cord as an Organ of Reflex Action."

THREE sculptors—Lessing, Hertert, and Janensch—have been selected from the list of those who made application to execute the statue of Helmholtz for the Helmholtz Memorial Committee. Which of the three will be chosen to carry out the work is not yet known. The monument will stand between the statues of the two Humboldts, in the front grounds of the University of Berlin.

WE much regret to announce the death of M. Antoine T. d'Abbadie, formerly president of the Paris Academy of Sciences. In 1893 M. d'Abbadie bequeathed to the Academy, subject to a life-interest to his wife, the Abbadia estate in the Pyrenees, having an annual revenue of twenty thousand francs, and shares in the Bank of France representing an annual income of fifteen thousand francs. He published several important works on geographical exploration and geodesy, and was sent by the Academy to St. Domingo in 1882 to observe the eclipse of the sun.

THE following are the names of the members of the British Association who have been nominated by the Council as presidents of the different Sections at the forthcoming meeting at Toronto:—(A) Mathematical and Physical Science, Prof. A. R. Forsyth, F.R.S.; (B) Chemistry, Prof. W. Ramsay, F.R.S.; (C) Geology, Dr. G. M. Dawson, C.M.G., F.R.S.; (D) Zoology, Prof. L. C. Miall, F.R.S.; (E) Geography, Mr. J. Scott Keltie; (F) Economic Science and Statistics, Prof. E. C. K. Gonner; (G) Mechanical Science, Mr. G. F. Deacon; (H) Anthropology, Prof. Sir W. Turner, F.R.S.; (I) Physiology, Prof. M. Foster, Sec.R.S.; (K) Botany, Prof. H. Marshall Ward, F.R.S. The two evening discourses will be delivered by Prof. Roberts-Austen, C.B., F.R.S., and by Prof. John Milne, F.R.S.

MR. MORRIS K. JESUP, president of the American Museum of Natural History, is fitting out an elaborate anthropological expedition to undertake a seven years' tour for the study of prehistoric man in all parts of the world, at a cost estimated as over sixty thousand dollars. It will be the most elaborate and best-equipped expedition ever sent out in the interests of anthropology. Mr. Jesup has already done much for scientific research. Several years ago he fitted out one of the relief expeditions to bring back Lieut. Peary from the Arctics. He also provided funds for the expedition under Prof. Charles S. Sargent, which collected the forestry exhibit known as the Jesup Collection in the American Museum of Natural History, a very complete exhibit of different kinds of wood in the United States. The expedition now contemplated will be led by Prof. F. W. Putnam, the veteran anthropologist, for a long time curator of the Peabody Anthropological Museum at Harvard University, and secretary of the American Association for the Advancement of Science. He will be assisted by Dr. Franz Boas, who has spent several years among the Indian tribes in the north-west of America, and by a corps of assistants. The plan is to proceed first to the north-west coast of North America, north of British Columbia, following the coast up to Alaska and Bering Strait. Thence the party will cross into Asia, and work down to Siberia, to China, along the Indian Ocean, and into Egypt.

A PUBLIC meeting to promote the National Jenner Memorial will be held in the theatre of the University of London, on Wednesday, March 31, at 4 p.m. The chair will be taken by the Duke of Westminster, K.G., and among those who will address the meeting will be Lord Herschell, Lord Playfair, Lord Lister, and Prof. Michael Foster.

PHYSICISTS who will be in Paris during Easter week should endeavour to visit the exhibition of new physical experiments and apparatus at the rooms of the Société Française de Physique, 44 rue de Rennes. The exhibition will be held on Friday, April 23, and Saturday, April 24. The principal experiments brought before the Society during the past twelve months will be repeated each evening at 8 p.m.; and the apparatus will be on view during the whole of the Saturday.

WE regret to have to record the deaths of Dr. Kolbe, formerly professor of mathematics at the Technical High School at Vienna; Dr. Robert Hogg, a distinguished horticulturist, and author of numerous works on the vegetable kingdom and its products; M. Charles Contejean, a young French physiologist known in the biological world by some important researches; Mr. Lorenzo N. Johnson, formerly instructor in botany in the University of Michigan; Prof. John Pierce, formerly professor of chemistry in Brown University, U.S.; and Mr. John Biddulph Martin, the president of the Royal Statistical Society, and a member of several other scientific societies.

AN instance of the solicitude shown by Government departments in Germany towards University professors is related by the Berlin correspondent of the *British Medical Journal*. It appears that Prof. Kayser, the successor of Hertz as Director of the Physical Institute in the University of Bonn, is invalided, and his symptoms seem to point to influences from insanitary surroundings. In consequence, the Prussian Cultus-Minister ordered a thorough examination into the institute building. Prof. Finkler, of Bonn, and Prof. Proskauer, Assistant at the Berlin Koch Institute, have been entrusted with the work, and will submit proposals for alterations, or even partial rebuilding, to the Medical Department of the Ministry.

THE present year being the sixtieth of Sir George Gabriel Stokes's connection with Cambridge, the wish has been expressed that his bust should be executed by some artist of eminence, and should be preserved in the Hall of Pembroke College, Sir G. G. Stokes having been a member of that college since October 1837. A working Committee has been formed for carrying out the proposal, and Mr. Hamo Thornycroft, R.A., has expressed his willingness to undertake the work of executing the bust. The Committee are desirous, if general support is given to the project, that a replica of the bust should also be executed, and presented to the University, in which Sir G. G. Stokes has held the Lucasian Professorship for nearly fifty years. For this double purpose a sum of not less than four hundred guineas will be required, of which amount about one-third has been given or promised. Donations may be paid to the credit of the "Sir G. G. Stokes Bust Fund" at Messrs. Barclay and Co., Mortlock's Bank, Cambridge, or to either of the Secretaries, Rev. C. H. Prior, and R. A. Neil, at Pembroke College.

THE Institution of Naval Architects have made arrangement to hold an International Congress of Naval Architects and Marine Engineers at the Imperial Institute, in the course of the coming summer. The Prince of Wales has consented to act as Honorary President of the Congress, and will deliver the speech of welcome on the opening day. Invitations to take part in the Congress have been sent to the Ministers of Marine of all the principal maritime powers of the world, to the French Association Technique Maritime, to the American Society of Naval Architects and Marine Engineers. A large and representative Reception Committee is in course of formation, and the Council are receiving every encouragement from H.R.H. the Prince of Wales, from the Government, the City of London, as well as from the shipbuilding and shipowning interests throughout the country. The exact date of the Congress is not yet fixed, but the meetings will probably take place early in July.

THE Comité d'Organisation of the seventh International Geological Congress, to be held at St. Petersburg from August 29 to September 4, have received so many applications from persons who are not geologists, and yet wish to obtain free railway tickets and to participate in other advantages arranged by the Russian Government, that they have issued a special circular stating that the facilities offered are intended only for geologists. Excursion tickets will only be granted to persons who are known by their contributions to geology. Even with this restriction, the meeting promises to be a large one, for more than six hundred geologists have applied for tickets. All geologists who have paid their subscription will obtain a non-transferable ticket, giving them the right to travel first-class on the Russian and Finland railways free of cost. The excursions arranged, both to precede and succeed the meeting, include a visit to the Urals, or to Esthonia, or to Finland, before the meeting, and to the Caucasus and Crimea after the meeting.

THE work upon "The Ancient Volcanoes of Great Britain," which has engaged Sir Archibald Geikie's attention for some time, will be published in a few days by Messrs. Macmillan and Co. The subject of the former volcanoes of the British Isles has occupied much of the author's time and thought all through his active life. Born among the crags that mark the sites of some of these volcanoes, he was led in his boyhood to interest himself in their structure and history. Since that time he has taken advantage of every opportunity of extending his knowledge of the phenomena they present, by personally examining the volcanic records of our own islands, and the volcanic regions of Europe and Western America. The forthcoming work will realise a long-cherished desire to combine the materials thus accumulated into a general narrative of the whole progress of volcanic action from the remotest geological period down to the time when the latest eruptions ceased. It is dedicated to Prof. Ferdinand Fouqué and M. Michel-Lévy, and will be a very important contribution to geological literature.

DR. NANSEN was present at the meeting of the Royal Geographical Society on Monday, when a paper on "The North Polar Problem" was read by Sir Clements Markham. In the course of some remarks upon the subject of the paper, he said that he thought the most interesting and important result of the recent expedition is with regard to the extension of land and sea in the north polar region. The whole of the sea to the north of Siberia was very deep, in fact it formed a north polar basin filled with comparatively warm water, and it could be asserted with great certainty that the Pole itself must be situated in that deep sea basin. The fact that the ice was always easily drifting north, indicated that there could not be much land to the north of their route, because if there had been land it must have stopped the drift of the ice in that direction. There were, also, no land birds to be seen flying northwards, whereas if land existed to the north they would have been certain to have seen some birds of that kind. There might, however, be some small islands to the north, where the ice-drift closed in from time to time in order to get into the layers which were noticed. The oldest ice met with in the polar region was probably of five or six years of age. The ice was, on an average, from 10 feet to 12 feet deep. As to the temperature of the water of the polar sea, it was always found to be pretty constant. At the top there was a layer of about 100 fathoms thick, the temperature of which just rose above freezing point, then the temperature began to sink, and just before the bottom was reached it rose again. This fact clearly shows that warm water must run into the polar sea from the south. The warm Atlantic water comes into the sea from the Gulf Stream, and forms a warm surface current there. That is perhaps the most important fact with reference to oceanography which has resulted from Dr. Nansen's expedition. Dr. Nansen concluded his remarks by saying that what is really wanted is not merely to reach the Pole, but more scientific observations from the Arctic regions. He did not think it was difficult to reach the Pole itself. With enough dogs it was quite possible. If 200 dogs were taken, the Pole could certainly be reached; but he did not think it was worth while, and he could not see the importance of it, for they would not bring back sufficient observations, and it would be a waste of time and labour. If they wanted scientific observations from the Arctic regions, there was no better plan than the one he adopted—of going into the ice. The ship was an excellent observatory; it was possible to have all kinds of laboratories on board. If he started again, he would build a better ship than the *Fram;* and if a man were to spend five years in such a ship, he was certain to bring back observations that would pay him many times over. He would be possessed of rich material for forming a good idea of the physical conditions of the North Polar region.

THE geometrical interpretation of complex quantity has hitherto been chiefly associated with the name of Argand; but it would now appear that this mathematician had been anticipated by a Norwegian named Caspar Wessel, who, on March 10 1797, communicated to the Academy of Sciences of Copenhagen a paper entitled, "Om Directionens analytiske Betegning" (on the analytic representation of direction). Caspar Wessel was a land-surveyor, who attained some distinction in his profession, but appears never to have been recognised as a mathematician; and this paper is remarkable both from being his only contribution to mathematical knowledge, and at the same time bearing distinct marks of mathematical genius. Not only did Wessel show how directed quantities could be represented in two-dimensional space by expressions involving $\sqrt{-1}$, but he also gave a theory of algebraic operations involving lines in three-dimensional space, thus anticipating Hamilton's theory of quaternions by nearly fifty years. To commemorate the centenary of the publication of this important paper, a French translation has been issued by the Danish Royal Academy, with prefaces by MM. H. Valentiner and T.-N. Thiele.

REFERRING to the plague in India, the *Lancet* remarks that the reports are, on the whole, more hopeful and promising, those from Bombay city showing a decided improvement. The total plague returns for Bombay city up to the 11th inst. amount to 9032 cases and 7546 deaths. The week's mortality from all causes in Bombay was 1326, as compared with 1484 in the previous week; and the returns for the whole Presidency since the outbreak of the plague up to the 6th inst. amount to 14,856 cases and 12,204 deaths. It will be remembered that many persons were disposed to think that there was some connection between the outbreak of plague and the storage of grain, and Surgeon-Colonel Waters some time ago gave an interesting account of his researches into the origin of plague, in which he adverted to the rat murrain that had been noticed in several of the outbreaks of bubonic disease, and to the plausible hypothesis that the disease might be connected with something affecting the granaries and the storage of the cheaper varieties of grain and millet. Mr. Hankin reports, however, that he has examined a large number of specimens of grain and flour under various conditions, but has been unable to detect the plague microbe in any of them, and that his examination of weevils and of other parasitic insects has also been with negative results. M. Haffkine has been busily occupied in developing a prophylactic and antitoxic serum. It is yet too early to pronounce any opinion on their efficacy, but the antitoxic curative serum has already been tried in many cases of plague with, so far, promising results. Dr. Yersin has prepared a stock of antitoxic serum, and we shall soon know whether the results obtained in India are confirmatory of those which were obtained, by others and himself, in China.

THE Agricultural Research Association does good service by disseminating trustworthy and useful information on agricultural subjects by means of scientific investigation. From the report, just received, we learn that the work done in 1896 was concerned chiefly with the cultivation of oats and the grass crop. With regard to the "dressing" or selection of oats for seed, it has been proved by experiment that, contrary to what might have been anticipated, large seeds afford no ground for expectation of the production of large ultimate plants or heavier crops, nor do they secure any earlier germination. What they do secure is power to reach the surface though deeply deposited, and a stronger briard, which will enable the plants to withstand uncongenial conditions of soil or season at the early stage of growth. The subject was further followed up to find why a large seed does not necessarily tend to produce a large plant. By this inquiry the fact has been found, by an investigation, that the size and strength of the embryo plant within the seed does not bear any relation to the size of the seed; small seeds may often contain larger or stronger embryos than a large seed; the extra size of the seed indicates merely the provision of extra food for the embryo. The production of a strong embryo probably depends rather on the parental influence, a circumstance which opens up an interesting subject that seems worthy of investigation, and one which might be expected to give results of practical value. Other work of the Committee refers to the proper time for harvesting oats, and the cultivation of suitable grasses. It is suggested that grass should lie longer than has hitherto been the practice. The Hon. Secretaries of the Association are:—Mr. Ranald Macdonald, Factor, Cluny Estates; Mr. John Milne, Mains of Laithers, Turriff. The Director of Research is Mr. Thomas Jamieson, 173 Union Street, Aberdeen.

THE presentation of the Albert Medal of the Society of Arts to Prof. D. E. Hughes, F.R.S., has induced our worthy contemporary—*Invention*—to disinter from the past the early history of the microphone. This instrument was invented in December 1877, and was first shown privately, in February 1878, to the officials of the Submarine Telegraph Company. The first demonstration of the discovery was made on May 2, 1878, at

Prof. Hughes' rooms. "Upon that occasion," remarks our contemporary (March 6), "besides the professor, there were present the late Prof. Huxley, Prof. Norman Lockyer, Mr. W. H. Preece, Mr. Conrad W. Cooke, and Mr. Perry F. Nursey. It is an idiosyncrasy with Prof. Hughes that his remarkable inventions have all been worked out with the most simple and commonplace tools. Thus on the occasion referred to the apparatus was of the most primitive character, and, with the exception of a Bell telephone receiver, could not be appraised at more than a few pence. This apparatus had a child's halfpenny wooden money-box for a resonator, on which was fixed by means of sealing-wax a short glass tube, filled with a mixture of tin and zinc, the ends being stopped by two pieces of charcoal to which were attached wires, having a battery of three small Daniell cells—consisting of three small jam-pots—in circuit. The wires were led away to a Bell telephone placed in an adjoining apartment. The money-box, which had one end knocked out, served as a mouthpiece or transmitter, while a Bell telephone was used as a receiver. Sounds scarcely audible, and some absolutely inaudible, to the unassisted ear, were by means of this apparatus delivered with startling loudness through the Bell telephone. Numerous experiments of the utmost importance to physicists were carried out by Prof. Hughes with this apparatus, and with modifications of it, all proving that he had succeeded in producing the simplest and most powerful electric articulating telephone ever known." The first public demonstration of the sensitiveness of the instrument took place at the Royal Society on May 8, 1878.

THE Royal Meteorological Society has for many years past held an exhibition annually, which has been devoted to some special class of meteorological instruments. This year an exhibition of meteorological instruments in use in 1837 and 1897 was arranged, in commemoration of the Diamond Jubilee of H.M. the Queen. The exhibition closed on Friday last. The instruments which were in use in 1837, as might be supposed, were not very numerous, but many of them were somewhat quaint and of great interest. Sir E. H. Verney, Bart., showed an old barometer with a large spirit thermometer, which latter had an arbitrary scale decreasing as the temperature increases, "extream cold" being 90° and "extream hot" 0°. The instruments in use during 1897 were, however, very numerous, and comprised various forms of barometers, thermometers, hygrometers, rain-gauges, anemometers, nephoscopes, sunshine recorders, actinometers, aneroids, electrical and miscellaneous instruments. Many of the instruments were self-recording, and were shown in action. The most interesting exhibit was a railed-off enclosure representing a typical climatological station of the Royal Meteorological Society. This included a Stevenson thermometer screen, fitted with dry bulb, wet bulb, maximum and minimum thermometers; rain-gauge; solar and terrestrial radiation thermometers; sunshine recorder, and earth thermometer; all of which were placed *in situ*. The exhibition also included a number of charts and photographs of great interest, particularly those by Mr. J. Leadbeater, of ice crystals on window-panes. Mr. W. H. Dines showed an experiment illustrating the formation of the tornado cloud, and Mr. Birt Acres exhibited some exceedingly interesting studies of form and movement of clouds and waves projected on the screen by his kinematoscope.

THE Mond gas-producer plant and its application, was the subject of a paper read by Mr. H. A. Humphrey at the Institution of Civil Engineers on March 16. The advantages of gaseous over solid fuel have led to an increasing demand for gas-producers to convert the solid fuel into the gaseous state. Gas-producers have hitherto been constructed to make gas with little regard to by-products, and none have been made to give good results with cheap slack coal, and where the use of gas for gas-engines has been concerned only expensive fuel, such as anthracite or coke, have been found available. But the Mond producer and recovery plant, described by Mr. Humphrey, not only employs cheap bituminous fuel, but recovers from it 90 lbs. of sulphate of ammonia per ton, and yields a gas eminently suitable for use in gas-engines and applicable to all cases of furnace work. The difficulties to be overcome before bituminous slack could be utilised in producers were many; nevertheless Dr. Ludwig Mond has not only succeeded in overcoming them, but has advanced the subject another stage by recovering as ammonia 70 per cent. of the original nitrogen contained in the fuel. The distinguishing features of the Mond process were enumerated, and the manner in which the plant is worked was described in detail.

STATISTICS of the United States Patent Office, just published, show an increase of about 3000 in the number of patents taken out during the last year compared with the year before. The surplus fund of revenues above expenses of the office now exceeds four million dollars.

REFERRING to our note on Prof. F. Plateau's experiments on the mode in which insects are attracted to flowers, Mr. G. W. Bulman calls our attention to a paper by him in the *Zoologist* (vol. xiv. 3rd series, p. 422), and to others published in *Science Gossip* between 1888 and 1892, in which he arrived at a conclusion similar to that of Prof. Plateau, viz. that the bright colour of the corolla does not act as a beacon to attract insects.

WE have received the first part of the division, "Aves," of the great new German zoological work, called "Das Tierreich," which is proposed to contain a descriptive synopsis of all the recent forms in the animal kingdom. The general editor of the whole work (on behalf of the German Zoological Society) is Dr. F. E. Schulze, of Berlin. The editor of the "Aves" is Dr. A. Reichenow, but the present part of that division has been prepared by Mr. Ernst Hartert, director of the Zoological Museum of Tring. There can be no doubt as to the merit of Mr. Hartert's work, which gives all that should be contained in such a synopsis, and no more. But it is a misfortune that German patriotism has rendered it necessary to use German instead of Latin in such a work, which is of a cosmopolitan nature. Multitudes of English and American zoologists, we regret to say, are still unable to read German with any sort of facility, while every one who has been to school understands a little Latin.

ABOUT two years ago Zelinsky found that two hydrocarbons could be obtained from hexamethylene iodide by reduction, the product prepared by means of zinc and hydrochloric acid being different from that got when hydriodic acid was used. Further experiments, of which an account is given in the current number of the *Berichte*, have convinced him that the first of these is the true hexamethylene; whilst the second is identical with the methylpentamethylene, which was first prepared by W. H. Perkin, jun., and P. Freer. The hexamethylene ring, therefore, under the influence of hydriodic acid at 230° changes into a more stable isomeric form. The nature of this change is quite in agreement with Baeyer's celebrated "tension-theory," according to which the pentamethylene ring is more stable than any other. It appears probable, moreover, that the hexahydrobenzene which is formed by the action of hydriodic acid on benzene, and which has long passed for hexamethylene, is in reality methylpentamethylene.

THE additions to the Zoological Society's Gardens during the past week include two Vulpine Phalangers (*Trichosurus vulpecula*, ♂ ♀) from Australia, presented by Mr. W. H. Stather; two Muscovy Ducks (*Cairina moschata*, ♀ ♀) from South

America, presented by Mrs. Dade; two Brown Mud Frogs (*Pelobates fuscus*) from Italy, presented by Count M. Peracea; an Indian Elephant (*Elephas indicus*, ♀) from India, a Rose-crested Cockatoo (*Cacatua moluccensis*) from Moluccas, deposited; a Chimachima Milvago (*Milvago chimachima*), two Violaceous Night Herons (*Nycticorax violaceus*) from South America, a Common Quail (*Coturnix communis*) captured at sea, a Common Rhea (*Rhea americana*) from South America, a Bornean Gibbon (*Hylobates muelleri*, ♀) from Borneo, purchased.

OUR ASTRONOMICAL COLUMN.

THREE BRILLIANT STELLAR SYSTEMS.—Prof. T. J. J. See, with the aid of the 24-inch refractor of the Lowell Observatory, in Mexico, has recently discovered (*Astr. Journal*, No. 396) three objects which "may be regarded as amongst the most splendid systems in the heavens." The first, discovered in January last, is α Phœnicis, its position for 1900 being R.A. 0h. 21m. 19·5s., decl. −42° 50′ 48″·1. The primary of this double has a magnitude of 2·4, the companion being as faint as a thirteenth mag. star. This inequality, combined with the deep orange or reddish colour of α Phœnicis, renders the system both striking and difficult. The mean of some measures made for determination of the position of the components was 1897·041, pos. angle 272°·7, dist. 9″·73. The second of these objects, also a very southern star, is μ Velorum with a magnitude of nearly 3, the companion being 11, of a purplish colour and very near the large star. [R.A. 10h. 42m. 28s., decl. −48° 53′ 31″ (1900)]. This system is described as one of the most extraordinary in the heavens, and likely to have a very large orbital motion. Measurements of position gave for 1897·059, pos. angle 62°·7, dist. 2″·54. The third and last of these objects, η Centauri,' situated at R.A. 14h. 29m. 10s., and decl. −41° 42′ 59″ (1900). The components are of magnitude 2·5 and 13·5, being yellow and purple in colour. The system is described as extremely difficult, requiring a powerful telescope to see it. The relative positions of the components is given for 1897·051, as pos. angle 270°·1, dist. 5″·65.

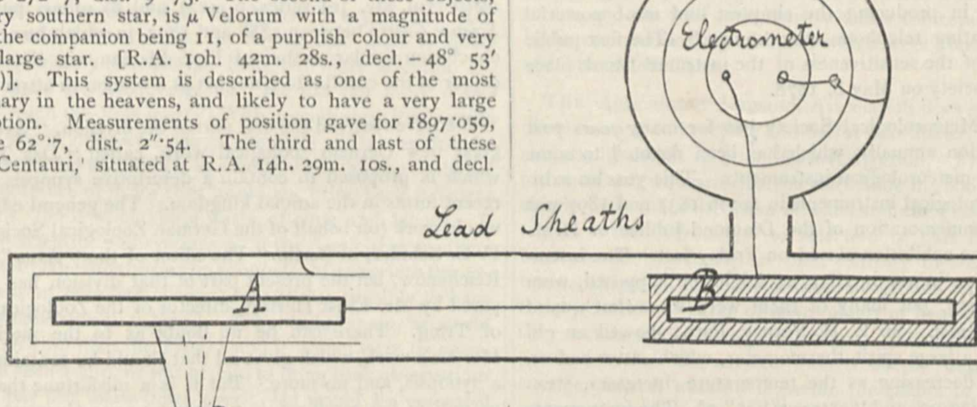
THE COMPANION TO PROCYON.—To those who wish to seek for the companion to Procyon, Prof. Schaerberle's description of the method he adopts (*Astr. Nachr.*, No. 3410) in observing this faint companion will prove of service. Owing to its very close proximity to Procyon, the companion can only be seen when the observing conditions are at their best. If a good objective be employed the aperture should not be reduced, but a cap fitted over the eyepiece is found most serviceable. For Prof. Schaeberle's measures an eyepiece magnifying 500 diameters was employed, the aperture of the cap over the eyepiece being about 1·6 millimetres. The magnitude of this companion is estimated as fully equal to a twelfth-magnitude star, and when the seeing is good it is "as easily and accurately measured as the satellite Phobos when Mars is in opposition." Sirius' companion is estimated as being two or three magnitudes brighter than that of Procyon, and is also being regularly observed at the Lick Observatory, the same means—namely, cap over the eyepiece—being employed.

ON THE INFLUENCE OF RÖNTGEN RAYS IN RESPECT TO ELECTRIC CONDUCTION THROUGH AIR, PARAFFIN, AND GLASS.[1]

WE have in previous papers described experiments respecting electric conduction when Röntgen rays fall on metals, positively or negatively electrified to potentials of two or three volts. We found that although air is rendered conductive, paraffin and glass are not rendered sensibly conductive when the differences of potential concerned are not more than two or three volts per centimetre of air, or per centimetre of paraffin, or per half-millimetre of glass.

We have now to describe an extension of the investigation to much higher voltages, in which we use an arrangement of two (quasi) Leyden jars, A and B, with their inside coatings connected together. The outside coating of A was connected to sheaths, the outside of B to the insulated terminal of the electrometer. In all the experiments to be described, B remained the same.

It consisted of a cylindrical lead can, 25 cms. long, 4 cms. diameter. A metal bar about 1 cm. diameter, 25 cms. long, was supported centrally on paraffin filling the whole space between it and the containing lead. This metal bar was connected by a wire to the internal coating of A. To protect this



wire from inductive effects, it was surrounded by a tube of lea connected to sheaths.

The Leyden A, which was placed opposite the Röntgen lamp, was different according as we were experimenting on the discharge through air, through paraffin, or through glass

To get a definite difference of potential, the two pairs of quadrants of the electrometer were first placed in metallic connection. Then one terminal of a battery or of an electrostatic inductive machine was connected to the internal coatings of the jars, and the other terminal to sheaths. The difference of potential produced was measured by a multicellular voltmeter in the case of differences under 500 volts, and on a vertical single vane voltmeter for higher differences.

When the desired difference of potential had been established, the metallic connection of the battery or electric machine with the internal coatings of A and B was broken, and this charged body left to itself. To find the loss due to imperfect insulation, the pair of quadrants in metallic connection with the outside coating of B was insulated in the ordinary way, and the deviation of the electrometer reading from the metallic zero per half-minute was observed. To find the loss when the rays were acting, the two pairs of quadrants were again placed in metallic connection, the Röntgen lamp set a-going, then the pair of quadrants connected to the outside coating of B was insulated from the other pair, and the deviation from metallic zero again observed per half-minute.

In the experiments with air, the Leyden A consisted of an aluminium cylinder, 16 cms. long, 3 cms. in diameter. This cylinder projected beyond the lead tube, and was connected to sheaths. The insulated metal inside it, which was a flat strip

1 By Lord Kelvin, Dr. J. Carruthers Beattie, and Dr. M. Smoluchowski de Smolan. Read before the Royal Society of Edinburgh, March 1.

of aluminium, about 10 cms. long and $1\frac{1}{2}$ cms. wide, cut from the same sheet as the surrounding aluminium tube, was supported at one end by a small piece of paraffin so placed as to be out of reach of the action of the Röntgen lamp. The rays from the lamp were allowed to pass from a lead cylinder surrounding it by a small hole about ·3 of a square cm. in area. They fell on the aluminium sheath transparent to them, and rendered the air between it and the insulated aluminium within conductive.

We tried various differences of potential, ranging from a few volts to 2200 volts. In one series of experiments we charged the insulated metal to −97·5 volts, and then disconnected the battery electrodes. The lamp was then set a-going, and the electrometer deviation taken each half-minute for a minute and a half with one pair of quadrants insulated. The rays were then stopped, the quadrants metallically connected, and metallic zero again found. Then the reading during another period of one and a half minutes, with the rays acting, was observed, and so on until no deviation from the metallic zero of the electrometer was found with one pair of quadrants insulated, and the rays falling on the aluminium outside coating of the Leyden A. The sensibly complete discharge thus observed took place in about a quarter of an hour. We found that the rate of deviation from the metallic zero was the same as the difference of potential fell from −97·5 volts to about −4 volts. With differences of potential of −930, −1750, and −2000 volts the rate of deviation was not appreciably greater than with ± 20 volts.

This confirms and extends, through a very wide range of voltage, the interesting and important discovery announced by J. J. Thomson and McClelland, in their paper in the Cambridge Philosophical Society *Proceedings* of March 1896, to the effect that the conduction of electricity through air under influence of the Röntgen rays is almost independent of the electric pressure when it exceeds a few volts per centimetre.

In the experiments on paraffin, the outside coating of the Leyden A consisted of an aluminium cylinder 27 cms. long, 4 cms. diameter, connected to sheaths. A metal bar about 1·75 cms. in diameter, and 30 cms. long, supported centrally on paraffin filling the whole space between it and the aluminium sheath, constituted the inside coating. With this arrangement we made experiments with differences of potential of ± 94, ± 119, ± 238, − 2000, + 2500, and − 2400 volts. At none of these potentials did we find any perceptible increase of conductance produced by the Röntgen rays above the natural conductance of the paraffin when undisturbed by them.

In the experiments with glass, the Leyden A consisted of a glass tube silvered on the inside. The inside silvering was placed in metallic connection with the inside coating of B. That part of the glass tube which projected beyond the lead sheath was covered with wet blotting-paper connected to the sheaths. We observed the behaviour of glass under the Röntgen rays at differences of potential of + 800, + 1500, + 2000 volts. We found no indication of increased conductance due to the rays at these voltages.

We are forced to conclude that the experiments described by J. J. Thomson and McClelland do not prove any conductance to be induced in paraffin or glass by the Röntgen rays. It seems to us probable that the results described in their paper —pages 7 and 8—are to be explained by electrifications induced on surfaces of glass or of paraffin in contact with air rendered temporarily conductive by the Röntgen rays.

THE INTRODUCTION OF BENEFICIAL INSECTS INTO THE HAWAIIAN ISLANDS.[1]

FEW countries have been more plagued by the importation of insect pests than the Hawaiian Islands; in none have such extraordinary results followed the introduction of beneficial species to destroy them. By far the most conspicuous of the former class, and hitherto the most injurious, have been the scale-insects. The number of species of this group, which have spread throughout the islands, is remarkable, and not less so the enormous multiplication of individuals of many or most of these species.

[1] Notes on the result of introducing predatory and parasitic insects into the Hawaiian Islands for beneficial purposes. Communicated by the Secretary of the Committee, appointed by the Royal Society and British Association, for investigating the Fauna of the Sandwich Islands.

The first importation of *Coccinelidæ* to destroy these hordes was made in 1890, when *Vedalia cardinalis*, Muls., a native of Australia, was sent over by Mr. Albert Koebele. At that time many trees were in a deplorable condition from the attacks of *Icerya*, monkey-pod trees being particularly badly infested—so much so that they were being largely cut down, as the only resource. The *Vedalia* was a complete success; it became perfectly naturalised, increased prodigiously for a time, practically cleared the trees, and then, as the *Icerya* became comparatively scarce, decreased in numbers; while at the present time it is evident that the number of the scale and its destroyer has arrived at a fixed proportion. Previously to its introduction here the same ladybird had done excellent service in the fruit orchards of Lower California.

The complete success of this first experiment was followed by the engagement of Mr. Koebele by the Hawaiian Government and planters for a term of years, to contend against other plagues no less serious than the *Icerya*. The wisdom of this course cannot be too highly commended, when compared with the indifference shown by the countries similarly circumstanced, and is a set-off against the reckless importation of infected plants which had been allowed in former years. Mr. Koebele, after seeing the wants of the country, with his unrivalled knowledge of the habits of *Coccinellidæ*, introduced numbers of other species in 1894, many of which, no doubt, failed to establish themselves, while a considerable number (how many is yet uncertain) have become completely naturalised, and done splendid service.

Before mentioning these, it may be said that the two chief products of the islands are sugar (which until lately has been far the most important export) and coffee, the cultivation of which has lately enormously increased. There is also a considerable amount of fruit grown; and this, too, is lately increasing. All these industries have been continually threatened with destruction from imported insects. The Rev. T. Blackburn, who studied the insects of the islands during six years—now nearly twenty years ago—wrote that the fruit trees were afflicted with incurable blight. Coffee plants were introduced in 1825. Its cultivation formed quite an industry in the middle of the century on Kauai, where only it was systematically cultivated; its growth was finally abandoned there in 1856, owing to the ravages of blight, said to have been imported in 1850. The sugar-cane has been, and is, attacked not only by scale-insects and *Aphides*, but by several other creatures of quite different orders.

To return now to the ladybirds: one of the most useful has been *Coccinella repanda*, Thun. (from Ceylon, Australia, China, &c.) which feeds on *Aphides*. The services of this species cannot be over-estimated. On Kauai recently the cane was so much attacked by an *Aphis* as to cause considerable alarm. On visiting the locality the *Coccinella* was found to be already present, breeding in such numbers as to leave little doubt that the plants would be soon cleared. On the same island, on another occasion, I saw the fruit trees (especially orange and lime) in a beautiful garden in a most deplorable condition from the attacks of *Aphis* and scales. Very few ladybirds could be found after a careful search. The owner was for spraying the trees, but, seeing their condition could not be much worse, I advised him to wait and give the beetles a chance. In a few weeks these were swarming; and when I returned, after six months, the infested trees were all in perfect condition, full of fruit and flower. Not less numerous than the preceding is a *Cryptolæmus* (*C. montrouzieri*) introduced from Australia, and thoroughly naturalised. It attacks the highly injurious species of *Pulvinaria*. When I visited the Kona district of Hawaii in 1892, many of the trees were literally festooned with the masses of this pest, and appeared on the point of being totally destroyed. In 1894 the ladybirds were sent there, and very soon had entirely changed the condition of things, and the affected trees speedily recovered. To show the vast increase of this species of ladybird, I may state that in June of the present year, many large trees in the city of Honolulu had several square feet of their bark entirely hidden by the larvæ, which formed great white masses, presenting such an extraordinary appearance that I much regret not having obtained photographs of some of the trees. At the present time this species and *Coccinella repanda* are far the most conspicuous and abundant of the introduced *Coccinellidæ*, either of them far outnumbering even the most abundant native insects. Their wide distribution is remarkable, for not only are they all over the lowlands, but throughout the mountain forests as high as four or five thousand feet above sea-level; indeed, the *Coccinella* is still higher up beyond the limits of the forest proper. Other introductions, some of which are extremely abundant, may be briefly noticed. The beautiful *Orcus chalybeus*, from Australia, is now widely spread and very common, feeding on *Lecanium*, *Pulvinaria*, *Diaspis*, &c. *Rhizobius ventralis*, Muls., from China and Ceylon, attacks that most abundant scale *Lecanium longulum*, and other species. *Chilocorus circumdatus*, from China and Ceylon, breeds freely on scales in Honolulu. Trees literally covered with *Mytilaspis* were entirely cleaned. Even the old dry scales were turned over in the search for food. *Platyomus lividigaster* has bred freely on orange *Aphis* in the city. *Scymnus debilis*, which in California feeds on *Dactylopius*, has become entirely naturalised. Other introductions, which have bred in the Islands, are *Chilocorus bivulnerus*, *Leis conformis*, *Synonyche grandis*, and *Novius Koebelei* (Fig., Rep. on Import. of Par. and Pred. Ins., by State Board of Horticulture, Sacramento, 1892.) There is little doubt that[1] other introduced species will turn up, when the city gardens and suburbs are systematically searched. Before the introduction of the species above mentioned, the only known Hawaiian *Coccinellidæ* were a few species (probably endemic) of *Scymnus* and *Coccinella abdominalis*, the latter, no doubt, accidentally imported from America many years ago. Unfortunately this species is attacked by a hymenopterous parasite, a *Braconid*, *Centistes americana*, Riley, which may interfere with the splendid work of *C. repanda*. The presence of this parasite is the more to be deplored, as such care was taken to exclude parasitised specimens when the introductions were made. This was very necessary, as the ladybirds seem very liable to the attack of parasitic Hymenoptera, especially the Australian species.

It is very pleasing to be able to refer to such successful results in the Hawaiian Islands, as in the United States Mr. Koebele's work has met with a good deal of adverse criticism. But it is not only by the introduction of ladybirds that Mr. Koebele has done such signal service, for he has had many other insect pests to contend with, which it is beyond the power of these to affect, attacking, as they do, but a very small portion of the insect world. In many parts of the islands, the bananas and palm-trees have been severely attacked by the larva of a species of *Pyralidina*. There is little doubt that in course of time this plague will be entirely kept under by a fine Chalcid (*Chalcis obscurata*, Walk.), introduced from China and Japan, which has already multiplied enormously at the expense of these caterpillars—so much so, indeed, that in many localities the trees have now entirely recovered. Again, within the last few years a Lamellicorn beetle (*Adoretus umbrosus*) has been introduced from Japan. This insect speedily multiplied prodigiously, and soon destroyed nearly every rose-tree in Honolulu, and subsequently attacked the foliage of many other trees. The cultivation of roses—once a feature of the city—became impossible, while a remedy seemed hopeless. One day, however, Mr. Koebele discovered a parasitic fungus, and by cultivation of this, and infecting healthy beetles, soon spread it far and wide. Whether the fungus will prove entirely effective is not at present certain, but in any case it will be a most useful aid. The writer has seen the ground under trees which were attacked, literally strewn with dead beetles—all killed by the fungus—and beneath the surface of the soil the larvæ had likewise perished. It is at least certain, therefore, that myriads of the beetles were destroyed very shortly after the fungus was spread around by the individuals that had been infected.

It becomes natural to ask why the success of the imported beneficial insects has been so pronounced here, while in other countries it has been attained in a comparatively small measure. The reason, I think, is sufficiently obvious. The same causes which have led to the rapid spread and excessive multiplication of injurious introductions, have operated equally on the beneficial ones that prey upon them. The remote position of the islands, and the consequently limited fauna, giving free scope for increase to new arrivals, the general absence of creatures injurious to the introduced beneficial species, and the equability of the climate, allowing of almost continuous breeding, may well afford results which could hardly be attained elsewhere on the globe. The keen struggle for existence of continental lands is comparatively non-existent, and, so far as it exists, is rather brought about by the introduced fauna than by the native one.

In conclusion, I cannot help turning to the darker side of the picture. What will be the result of all these importations on the endemic fauna? The introduction of many other species—parasitic and predaceous—is contemplated, and will be performed. That success, from an economic point of view, will be attained there is little doubt, and while industries are threatened, or even the gratification of æsthetic tastes, it is certain that no consideration will be given to the native fauna. When even now the ladybirds are affecting the latter, what will be the result of the introduction of more widely predaceous species? The effect of the former is not imaginary, but proven. In June 1895, in a lovely forest in Hawaii—5000 feet above sea-level—I found the native trees much affected by a black *Aphis*. By beating these trees the blight came down in abundance, and amongst them various fine species of endemic *Chrysopa* and *Hemerobius*, predatory creatures. One or two introduced ladybirds were also noticed. By September the ladybirds were in thousands, the blight and native insects in small numbers. In August 1896 not an *Aphis* was to be found, and only one or two stray specimens of ladybirds, as one may find anywhere throughout the forests. They had done their work and disappeared. This is a high testimonial as to the capabilities of the beetles, and as the existence or non-existence of Hawaiian *Chrysopa* is not likely to be regarded by people at large, and seeing that sooner or later the greater part of this most interesting native fauna is, under any circumstances, in all probability doomed to extinction, it only remains to wish Mr. Koebele a success in the future equal to that which he has already attained.

Honolulu, H.I., November 1896. R. C. L. PERKINS.

[1] Since writing the above several other species have been found, which have evidently bred in the country.

MARINE ORGANISMS AND THE CONDITIONS OF THEIR ENVIRONMENT.[1]

THE ocean may be divided into two great biological regions, viz. the superficial region, including the waters between the surface and a depth of about 100 fathoms, and the deep-sea region extending from the 100 fathoms line down to the greatest depths. The superficial region may be subdivided into two provinces, viz. the shallow-water or neritic province around the land masses where the depth is less than 100 fathoms, and the pelagic province, embracing the superficial waters of the ocean basins outside the 100 fathoms line; these two provinces contrast sharply as regards physical conditions, which are of great variety in the neritic province, and very uniform over wide areas in the pelagic province.

Temperature is a more important factor in determining the distribution of marine organisms, mostly cold-blooded, than in the case of terrestrial species, mostly warm-blooded and air-breathing animals, the distribution of which depends rather upon topographical features than upon climatic conditions.

A map was exhibited showing the range of temperature in the surface waters of the ocean all over the world, and indicated northern and southern circumpolar areas with a low temperature and small range (under 10° F.), and an almost circumtropical area with a similar small range but high temperature; in temperate regions the range is greater, the areas of greatest range (over 40° F.) being found off the eastern coasts of North America and of Asia and south of the Cape, due to the mixture of currents from different sources, which sometimes causes the destruction of enormous numbers of marine invertebrates and fishes.

The pelagic tropical waters of the ocean teem with various forms of life, of which probably 70 to 80 per cent. function as plants, converting, under the influence of sunlight, the inorganic constituents of sea-water into organic compounds, thus forming the original source of food of marine animals both at the surface and at the bottom of the sea.

The number of species living in the pelagic waters of the tropics may greatly exceed the number in polar waters, where, on the other hand, there is often a great development of individuals, so that there is probably a greater bulk of organic matter in the cold polar waters than in the warm tropical waters. The rate of animal metabolism is slower at a low than at a high temperature, and organisms inhabiting tropical waters probably pass through their life-history much more rapidly than similar organisms living in polar regions. Carbonate-of-lime-secreting organisms are most abundant in the warm tropical waters, decreasing in numbers towards the polar regions, and it has been shown that the precipitation of carbonate of lime from solution in sea-water takes place much more rapidly at a high

[1] An address delivered at the Royal Institution by Dr. John Murray, F.R.S.

temperature. The pelagic larvæ of bottom-living species are always present in the warm surface waters of the tropics, sometimes growing to an enormous size; but they are absent from the cold polar waters and in the deep sea, where the majority of the bottom-living species have a direct development.

The Arctic fauna and flora, both at the surface and at the bottom, resemble the Antarctic fauna and flora, and a large number of identical and closely-related species are recorded from the two polar areas, though quite unknown in the intervening tropical zone.

The boundary line between the deep-sea region and the neritic province is marked out by what has been called the "mud-line," where the minute organic and inorganic particles derived from the land and surface waters find a resting place upon the bottom, or serve as food for enormous numbers of crustacea, which in their turn are the prey of fishes and the higher animals; this mud-line, in fact, appears to be the great feeding-ground in the ocean, and its average depth is about 100 fathoms along the borders of the great ocean basins.

The majority of deep-sea species are mud eaters; some are of gigantic size; some are armed with peculiar tactile, prehensile, and alluring organs; some are totally blind, whilst others have large eyes and are provided with a kind of dark lantern for the emission of phosphorescent light. The deep-sea fauna does not represent the remnants of very ancient faunas, but has rather been the result of migrations from the region of the mud-line in relatively recent geological times.

The *Challenger* investigations show that species are most abundant in the shallow waters near land, decreasing in numbers with increasing depth, and especially with increasing distance from continental land.[1] This is true as a general rule, especially of tropical waters, but in polar regions there are indications of a more abundant fauna in depths of 50 to 150 fathoms than in shallower water under 50 fathoms.[2]

The various points touched upon regarding the distribution of marine organisms, might be explained on the hypothesis that in early geological times there was a nearly uniform high temperature over the whole surface of the globe, and a nearly uniformly distributed fauna and flora; and that with the gradual cooling at the poles, species with pelagic larvæ were killed out or forced to migrate towards the tropics, while the great majority of the species which were able to survive in the polar areas were those inhabiting the mud-line. The uniform physical conditions here referred to might be explained by adopting the views of Blandet[3] as to the greater size and nebulous character of the sun in the earlier ages of the earth's history.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Dr. J. N. Langley, F.R.S., and Mr. A. C. Seward, Lecturer in Botany, have been appointed additional members of the Degree Committee of the Board for Biology.

Mr. F. F. Blackman, of St. John's College, has been appointed University Lecturer in Botany.

The special numbers of the *University Reporter* containing the Report of the Syndicate on Degrees for Women, and the speeches made in the three days' discussion thereupon in the Senate House, can be obtained (price 7*d.*) by application to the University Press, Cambridge.

DR. ALEXANDER J. C. SKENE, president of the Medical College of the Long Island College Hospital of Brooklyn, has received the degree of LL.D. from the University of Aberdeen, his native city.

MR. JOHN D. ROCKEFELLER has given 40,000 dollars to Mount Holyoke College, in Massachusetts. This is a college for women, which a few months ago met with heavy loss by the burning of its buildings.

MRS. E. A. STEVENS, widow of the founder of the Stevens Polytechnic Institute, has given to that Institute property valued at 30,000 dollars, since the quarter-century celebration held a few days ago.

[1] See "*Challenger* Reports," "A Summary of the Scientific Results," by John Murray, pp. 1430–1436, 1895.

[2] See Murray, "On the Deep and Shallow-Water Marine Fauna of the Kerguelen Region of the Great Southern Ocean," *Trans. Roy. Soc. Edin.*, vol. xxxviii. p. 343, 1896.

[3] *Bull. Soc. géol. de France*, sér. 2, t. xxv. p. 777, 1868.

IT is stated that M. Solvay, who owns large industrial establishments in the neighbourhood of Nancy, has given 100,000 francs to the university of that city, for the purpose of erecting a chemical and electrical laboratory.

THE Senate of the University o. Glasgow have resolved to confer the honorary degree of LL.D. upon Mr. J. Wolfe Barry, C.B., F.R.S., President of the Institution of Civil Engineers, London; Prof. John M'Cunn, Professor of Philosophy in University College, Liverpool; and Prof. W. Ramsay, F.R.S., Professor of Chemistry in University College, London.

A BLUE-BOOK just published shows that the total amount expended by local authorities on technical education during the year 1894–5 was 737,809*l.* 5*s.* 4*d.*; and that the estimated total expenditure on technical education during the year 1895–6 was 793,507*l.* 17*s.* 7*d.* These amounts are exclusive of the sums allocated to intermediate and technical education under the Welsh Intermediate Education Act, and amounting to 42,861*l.*

THE following are among recent announcements:—Dr. Hans Lemke to be assistant at the meteorological and magnetic observatory at Potsdam; Prof. Simmara to be professor of physiological psychology in the Government School of Science at Madrid; Dr. E. Vischer, associate professor of botany at Bern, to be professor and director of the Botanic Gardens there; Dr. Ross to be curator of the Botanical Museum at Munich; Dr. J. Y. Mackay, professor of anatomy, to be principal of the University College, Dundee; Prof. P. Baccarini to be professor of botany in the University of Catania; Dr. O. Kruch to be professor at the agricultural experiment station in Perugia; Dr. W. Felix to be associate professor of anatomy in the University of Zürich.

A COMPARISON of the number of hours devoted to different departments in four Universities in the United States is made in *Science*. The following table shows the relative attention given to different branches of knowledge.

	Harvard.	Cornell.	Yale.	Princeton.
Classics	8·7	8·0	24·2	22·6
European languages	22·8	18·8	14·5	12·4
English	16·8	16·3	10·9	11·3
Political science	9·9	6·5	11·2	9·6
History	14·3	8·2	10·4	
Mathematics	4·4	6·6	9·6	19·4
Philosophy	6·1	7·7	8·9	8·6
Natural science	10·2	23·5	8·1	8·8

It is pointed out by *Science* that Yale and Princeton agree somewhat closely in the distribution of studies, except for the excess in mathematics at Princeton. Harvard and Cornell also agree to a considerable extent, but Cornell devotes one-fourth of the entire time (the figures refer to the academic department) to science. It is noteworthy that in the Senior year at Princeton, when the studies become elective, only 3·8 per cent. of the time is given to the classical languages, and 15·1 per cent. to natural and physical sciences. The classical languages evidently only hold their position at Yale and Princeton through compulsion. European languages tend to take their place in large measure with some gains by English and the sciences.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, March 4.—"The Palæolithic Deposits at Hitchin and their Relation to the Glacial Epoch." By Clement Reid, F.L.S., F.G.S., of the Geological Survey of the United Kingdom. Received February 15.

In continuation of the researches at Hoxne, communicated last autumn to the British Association, excavations and borings have been made at Hitchin, with the object of ascertaining whether the conclusions arrived at are supported by the study of a fresh locality. The results obtained at Hitchin are thoroughly in accord with those obtained at Hoxne. At each place brick-earth with Palæolithic implements can be proved to overlie the latest boulder clay of the district. At Hoxne the Palæolithic deposits were shown to be separated from the boulder clay by two distinct alluvial deposits, the newer of which yields an arctic flora, the older a temperate one. The arctic plants have not yet been discovered at Hitchin, but abundance of temperate species occur in the older alluvium.

At each locality the same story is told. Some time after the passing away of the ice the land stood higher than now, so that the streams had a greater fall and valleys were cut to a somewhat greater depth. Then the land sank and the valleys became silted up with layer after layer of alluvium, to a depth of at least 30 feet, the climate remaining temperate. The next stage, when an arctic flora reappeared, is only represented at Hoxne. The third stage in the infilling of the valleys is shown in the curious unstratified decalcified brick-earth with scattered stones and Palæolithic implements, identical in character at Hitchin, Hoxne, Fisherton, and other localities, which irresistibly suggests a mingling of wind-transported material and rain-wash.

It may be pointed out that if this hypothesis of the origin of the Palæolithic brick-earth during the reign of "steppe" conditions be accepted, it will account for the non-correspondence of the ancient channels with the present valleys, a thing very difficult to explain if the infilling were caused by ordinary fluviatile action. If the Palæolithic brick-earth is equivalent to the Palæolithic loess of the ancient deserts in central Europe, we can understand how during this period of cold drought the smaller streams ceased to flow and their valleys became so filled with rain-wash and dust that when a moister climate recurred the streams had to seek new channels.

March 11.—"The Origin and Destination of certain Afferent and Efferent Tracts in the Medulla Oblongata." By J. S. Risien Russell, M.D., M.R.C.P.

In attempting to ascertain the origin and destination of some of the tracts of nerve fibres which exist in the medulla oblongata by the degeneration method, many of these tracts were divided, and among them the posterior connections of the cerebellum, and, similarly, certain nerve centres situated in the medulla were severed from their connections with the rest of the organ.

Among other results obtained by these experiments the author finds, in support of his previous contentions based on results obtained by ablation of the cerebellum, that while paths derived from the spinal cord can be traced directly to the cerebellum, no direct path can be traced from the cerebellum to the spinal cord. He, however, finds that an indirect path of this kind exists, and that the first portion of it is what was formerly regarded as a sensory tract passing from the medulla oblongata to the cerebellum, but which is in reality a path from the cerebellum to a special group of nerve cells in the medulla known as Deiters' nucleus, from which another tract of fibres originates which can be traced throughout the whole length of the spinal cord, and which becomes connected with the anterior horn of the same side, and to a lesser degree with that of the opposite side.

The author further finds that there are other important connections of these nerve cells known as Deiters' nucleus, with the corpora quadrigemina, superior olivary bodies and the cervical region of the spinal cord by way of the posterior longitudinal bundles. The cerebellum is thus brought into relationship with these various nerve centres in a way that suggests that these connections may have important bearings in regard to the movements of the head and eyes.

Chemical Society, March 4.—Mr. A. G. Vernon Harcourt, President, in the chair.—The following papers were read:—Some hydrocarbons from American petroleum. (1) Normal and iso-pentane, by S. Young and G. L. Thomas. By fractional distillation of "pentane" from American petroleum, the authors have obtained pure normal and iso-pentane; the boiling points under normal pressure are 36·3° and 27·95° respectively.—The vapour pressures, specific volumes and critical constants of normal pentane, with a note on the critical point, by S. Young. The critical data of normal pentane are 197·2°, 25100 mm., and 4·303 c.c.; the thermal and other data obtained lead to the conclusion that in the liquid state and at the critical temperature the molecules of pentane are simple ones, as in the gaseous state.—On the freezing-point curves of alloys containing zinc, by C. T. Heycock and F. H. Neville. The melting-point curves of binary alloys of zinc with cadmium, aluminium, tin and bismuth have been examined and the compositions of the eutectic mixtures determined; dilute zinc solutions containing lead, thallium, antimony and magnesium were also examined. The freezing point of zinc is depressed by admixture with the metals named above, but is raised by addition of copper, gold, or silver.—The oxides of cobalt and the cobaltites, by A. H. McConnell and E. S. Hanes. The authors describe the preparation of alkali cobaltites, and show that cobalt forms an oxide CoO_2, an acid H_2CoO_3, and a series of alkali salts of the type of potassium cobaltite K_2CoO_3.—A new synthesis in the sugar group, by H. J. H. Fenton. Glycollic aldehyde condenses when heated in a vacuum, giving a sweet-tasting gum of the composition $C_6H_{12}O_6$; this "sugar" yields a hexosazone $C_{18}H_{22}N_4O_4$, and is not fermented by yeast. When heated it loses water, apparently yielding compounds of the compositions $C_{12}H_{22}O_{11}$ and $C_6H_{10}O_5$.—The dinitrosamines of ethyleneaniline, the ethylene toluidines and their derivatives, by F. E. Francis.—Contribution to the knowledge of the β-ketonic acids, Part v., by S. Ruhemann and A. S. Hemmy.—Enantiomorphic forms of ethylpropylpiperidonium iodide, by Miss C. de B. Evans. Ethylpropylpiperidonium iodide, $C_5H_{10}EtPrNI$, crystallises in right- and left-handed enantiomorphous crystals just as sodium chlorate does.—Further note on ketopinic acid—pinophanic acid, by W. S. Gilles and F. F. Renwick. Ketopinic acid yields a hydroxime and a monobrom-derivative, and when fused with soda is converted into a dibasic acid $C_{10}H_{16}O_4$, which is termed pinophanic acid.—A synthesis of citric acid, by W. T. Laurence. Ethylic citrate is synthetically obtained by the condensation of ethylic bromacetate with ethylic oxalylacetate in presence of zinc as indicated by the following equations: (1) $COOEt.CH_2Br + COOEt.CH_2.CO.COOEt + Zn = COOEt.CH_2.C(OZnBr)(CH_2.COOEt).COOEt$. (2) $COOEt.CH_2.C(OZnBr)(CH_2.COOEt)COOEt + H_2O = COOEt.CH_2.C(OH)(CH_2.COOEt).COOEt + ZnO + HBr$.

Linnean Society, March 4.—Dr. A. Günther, F.R.S., President, in the chair.—Mr. W. Carruthers, F.R.S., exhibited, with the aid of lantern-slides, a series of portraits of Linnæus, and gave some account of the history of each. In the course of a tour which he had made in Sweden and Holland, he had been fortunate enough not only to see the original paintings, but also to obtain photographs of them, so that he was now able to exhibit exact copies. Putting aside "supposed portraits," and such as might be termed "fancy portraits" having no claim to authenticity, he had satisfied himself of the existence of eight that were certainly painted or drawn from life, and had been copied more or less frequently by different engravers. The earliest of these was painted by Hoffman in 1737, while Linnæus was working for his patron Cliffort at Hartecamp, and represents him at the age of thirty in the picturesque dress in which he travelled through Lapland. Of the next portrait, an engraving by Ehrensverd in 1740, no original is known to exist. In 1747, at the age of forty, two pencil sketches of Linnæus, one being a full length, were made by Rehn; and five years later a beautiful pastel was executed by Lundberg. Scheffel in 1755 painted him at the age of forty-eight; and this portrait is preserved at Hammarby in the house of Linnæus, now public property under the care of Prof. Fries of Upsala. Then came the medallion by Inlander, executed in 1773, of which a copy (one of three) is in possession of this Society. The following year, when Linnæus was sixty-seven years of age, his portrait was painted by Krafft, and was placed originally in the Medical College of Stockholm, of which Linnæus was one of the founders. It was supposed to be lost, but had been removed to the Royal Academy of Sciences in Stockholm, where Mr. Carruthers discovered it. The latest portrait was that by Roslin, painted in 1775, when Linnæus was in his sixty-eighth year. A fine copy of this by Pasch, presented to Sir Joseph Banks, and given by him to Robert Brown, now hangs in the Society's library.—Dr. W. B. Benham read a paper on some new species of earthworms belonging to the genus *Perichæta* from New Britain and elsewhere, with remarks on certain diagnostic characters of the genus.—On behalf of Mr. W. G. P. Ellis, Demonstrator in Botany at the University Botanical Laboratory, Cambridge, the Secretary gave the substance of a paper "On a *Trichoderma* Parasitic on *Pellia epiphylla*."

Geological Society, March 10.—Dr. Henry Hicks, F.R.S., President, in the chair.—Volcanic activity in Central America in relation to British earthquakes, by A. Gosling, H.M. Minister and Consul-General in Central America. The author of the communication points out that the volcano of Izalco, in the Republic of Salvador, which has been in active eruption for over one hundred years, suddenly ceased to be so within a fortnight of the period at which the communication was sent (December 20, 1896), and he notes the occurrence of seven shocks of earthquake in England on December 17, 1896. He quotes remarks concerning the volcano, which were contributed by him to the *North American Review* in January 1896.—The red rocks near Bonmahon on the coast of Co. Waterford, by F. R. C. Reed. The rocks considered in this paper have been regarded by some authorities as deposits interstratified with the Lower Palæozoic rocks of the district, while others have maintained that they are of Old Red Sandstone age. It was the object of the author to show the correctness of the latter supposition, and he brought forward evidence to prove that the red rocks rest unconformably upon the Lower Palæozoic rocks, or are faulted against them, and that the breccias of the red rocks contain fragments of the Lower Palæozoic rocks, and also of intrusive rocks which break through the latter. The red rocks also resemble deposits which are known to be of Old Red Sandstone age.—On the depth of the source of lava, by J. Logan Lobley. The author contended that lava could not have been brought to the surface from a depth of thirty miles, as fissures which would serve as conduits could not exist at that depth, and, moreover, the lava would be consolidated before it reached the surface, owing to contact with cool rock for a considerable period. He argued that the pressure of the overlying rocks would cause the rocks even at a depth of ten miles to be practically plastic, as shown by M. Tresca's experiments, and that no continuous fissure could occur in such rocks. Estimates of the volumes of ascending lava-columns were given, with a diagram comparing them with a 30-mile thickness of rocks.

Mathematical Society, Thursday, March 11.—Prof. Elliott, F.R.S., President, in the chair.—The President referred to a letter received from the President of the Royal Society with reference to the Victoria Research Fund, which it is proposed to institute in commemoration of Her Majesty's long reign, and commended the fund to the generous consideration of the members. He next spoke briefly on the loss the mathematical world had sustained by the recent death of Prof. Weierstrass.—Mr. Jenkins, Vice-President, having taken the chair, the President communicated a paper, by Mr. J. E. Campbell, on a law of combination of operators bearing on the theory of continuous transformation groups.—On resuming the chair, the President read some notes on symmetric functions, by Mr. W. H. Metzler.—The Senior Secretary briefly communicated a note on some circles connected with a triangle, by Prof. Steggall.—Lieut.-Colonel Cunningham, R.E., mentioned three high primes recently determined by him—85,280,581; 234,750,601; 2,413,941,289; and gave a sketch of the methods used.

Zoological Society, March 16.—Dr. W. T. Blanford, F.R.S., Vice-President, in the chair.—Mr. Sclater called attention to the two specimens of otters, now living in the Society's Gardens, which had been received from Co. Down, Ireland, last year, and pointed out that they differed in several respects from the common otter.—Mr. A. Smith Woodward gave an account of his recent palæontological tour in Brazil and Argentina, and made remarks on the fossil remains of vertebrated animals that had come under his observation in those countries.—Dr. R. H. Traquair, F.R.S., exhibited and made remarks upon a new specimen of the supposed fossil lamprey (*Palæospondylus gunni*) from the Old Red Sandstone of Caithness, and read a note on its affinities.—A communication was read from Dr. Robert Collett, on a collection of mammals made by Mr. Knut Dahl in North and North-west Australia in 1894-96. The collection contained specimens of thirty four species, two of which—viz. *Pseudochirus dahlii* and *Smithopsis nitela*—proved to be new to science. The former species had been described in the *Zoologischer Anzeiger* for 1895; the latter was characterised in the present paper.—Mr. P. L. Sclater, F.R.S., read a paper "On the Distribution of Marine Mammals." The marine area of the globe was divided into six sea-regions, viz. Arctatlantis, Mesatlantis, Indopelagia, Arctirenia, Mesirenia, and Notopelagia, which corresponded to a certain extent with the six land-regions proposed by Mr. Sclater in 1874. The characteristic mammals of each sea-region were pointed out.—Mr. F. E. Beddard, F.R.S., read a paper on a collection of earthworms from South Africa, belonging to the genus *Acanthodrilus*, which had been made in the Cape Colony by Mr. Purcell, of the South African Museum, and forwarded to him by Mr. W. L. Sclater. Examples of nine new species were contained in the collection, which fact was of great interest, as previously only one representative of the genus *Acanthodrilus* had been known to exist in South Africa. Mr. Beddard also described a new genus of earthworms, belonging to the family *Eudrilidæ*, from Lagos, West Africa, under the name of *Iridodrilus*.—Dr. Forsyth Major exhibited a series of skulls and photographs of species of the African bush-pigs (*Potamochœrus*), and pointed out the characters of a new species from Nyasaland, which he proposed to call *P. johnstoni*, remarkable for its large size and slender snout. He also showed that the *Nyctichœrus hassana* of Heuglin, from Abyssinia, formed a distinct species of *Potamochœrus*.

EDINBURGH.

Royal Society, March 1.—Lord Kelvin in the chair.—The Chairman exhibited models illustrating the dynamical theory of hemihedral crystals.—Mr. R. C. Mossman read a second paper on the meteorology of Edinburgh during the past 138 years. There had been no appreciable change in the climatic conditions during that period. The graphs showed nothing approaching to weather cycles. Great snowstorms prevailed during the first quarter of the present century, and during the past twenty-five years there had been an unusually large number of thunderstorms.—Prof. Tait read a paper on the linear and vector function.

Mathematical Society, March 12.—Mr. J. B. Clark, Vice-President, in the chair.—The following papers were read:—Note on combinations, Mr. J. B. Clark.—Note on maxima and minima, Mr. J. Alison.—An application of Sturm's functions, Mr. J. D. Höppner.—A geometrical proof of certain trigonometrical formulæ, Mr. J. W. Butters.

PARIS.

Academy of Sciences, March 15.—M. A. Chatin in the chair.—The election of M. G. Bonnier in the Section of Botany, in the place of the late M. Trécul, was approved by the President of the Republic.—A new apparatus for the application of spectrum analysis to the recognition of gases, by M. Berthelot. The gas is contained at ordinary atmospheric pressure over mercury in a short glass tube carrying one of the platinum wires, the other terminal being fused into a smaller glass tube, capable of vertical adjustment. The regulation of the striking distance of the spark is of considerable importance in this apparatus, the results obtained in which, although not so delicate as in tubes containing rarefied gas, are still sufficiently good for practical analysis.—On the electric absorption of nitrogen by carbon compounds, by M. Berthelot. A preliminary study showed that much more rapid absorption took place when the induction coil was fitted with a Marcel Deprez high-speed interrupter than when a low-speed vibrator of the Foucault pattern was used. The maximum amount of nitrogen absorbed by a given weight of benzene was 12 per cent. by weight, by carbon bisulphide 11·7 per cent., and by thiophene 8·6 per cent., corresponding to the ratios $3C_6H_6 : N_2$; $3CS_2 : N_2$; and $4C_4H_4S : N_2$. The absorption was most rapid when carbon bisulphide was used, and in presence of an excess of either this or of benzene, the last trace of nitrogen could be completely absorbed.—On the theory of algebraic surfaces from the point of view of geometry of position, and on the integrals of total differentials, by M. Émile Picard.—On a property of asynchronous motors, by M. A. Potier.—Studies on the energy changes in living muscle, by M. A. Chauveau. An inquiry into the relations between the law of conservation of energy and the work done by living muscles. In a comparison of the elastic properties of muscle and india-rubber, it is of the highest importance that the muscle should be living, the elastic properties of muscular tissue separated from the body being quite different from those of the same muscle in the living state. This precaution being observed, there is complete analogy between the elasticity of india-rubber and muscular tissue.—On the relations expressing that the various coefficients considered in thermodynamics should satisfy the law of corresponding states, by M. E. H. Amagat.—On the systems of orthogonal and isothermal surfaces, by M. A. Pellet.—On the method of successive approximations of M. Picard, by M. S. Zaremba.—On the spark discharges and the use of the Hertz oscillator, by M. Swyngedauw. The spark resistance, considered as the resistance of a bad conductor, is regarded by the author as depending upon its length, section, temperature, and the nature of the luminous conductor which constitutes the spark. The consequences of this point of view are different to those deduced by Thomson, who regarded the resistance as constant, and lead to the result that the discharge of a condenser, oscillating for large capacities, becomes continuous for capacities sufficiently small. The Hertz exciter is a condenser of small capacity, and the preceding considerations are applied to it.—On the action of the silent electric discharge upon gases, by M. Émile Villari. Gases which have acquired the property of discharging electrified bodies either by having been sparked, or by having been traversed by the X-rays, lose this power when submitted to the silent discharge of an ozone apparatus. This neutralising power of the ozoniser persists for a certain time after disconnecting it from the coil, the effect being produced by the accumulated charges on the glass.—

Action of high temperatures upon antimony peroxide, by M. H. Baubigny. At a temperature just above the melting-point of gold, antimony peroxide is almost completely decomposed into oxygen and the volatile antimony trioxide.—Action of tannin and some other aromatic derivatives upon some alkaloids and compound ureas, by M. Œchsner de Coninck.—On some derivatives of anethol, by M. Georges Darzens. The unsaturated nature of anethol was shown by the formation of a chlorine derivative by addition. The chlorine was used in carbon tetrachloride solution, a very convenient form of using chlorine in known amounts. This derivative cannot be distilled, as it readily splits off hydrogen chloride, leaving a monochloranethol from which, by addition of chlorine and bromine in carbon tetrachloride solution, the corresponding saturated halogen compounds were prepared.—On the combination of iodine with rice and wheat starch, by M. G. Rouvier.—On the solubility of the red colouring matter of the raisin, and on the sterilisation of the expressed juice of fruit, by M. A. Rosenstiehl.—On the Japanese and Chinese vines acclimatised at Damigny (Orne), and on the composition of the wines which they produce, by M. L. Lindet.—On the composition of the ancient Indian pottery of Venezuela, by M. F. Geay.—Refractory period in the nervous centres, nervous wave, and consequences which result, from the point of view of cerebral dynamics, by MM. André Broca and Charles Richet.—On a new anatomical apparatus observed in the peritoneum, by M. J. J. Andeer.—On some anatomical peculiarities observed in the larva of *Thriaxion Halidayanum*, by M. J. Pantel.—On the relations of *Antennophorus Uhlmanni* (Haller) with *Lasius mixtus* (Nyl), by M. Charles Janet. The *Antennophorus* are parasites living on the *Lasius*, and are nourished by a nutritive fluid exuded by the ants. The parasites always place themselves symmetrically about the body of their host, so that his movements are impeded as little as possible.—On some points in the geology of the environs of Bourganeuf (Creuse), by M. Ph. Glangeaud.—On the use of formaline in the preparation of microscopic specimens, after hardening with osmic acid, by M. Ch. Rousselet.—Synthesis of the elementary forces, by M. Bridou.

DIARY OF SOCIETIES.

THURSDAY, MARCH 25.

ROYAL SOCIETY, at 4.30.—Meeting for Discussion. *Subject*: The Chemical Constitution of the Stars, introduced by J. Norman Lockyer, C.B., F.R.S., with a Communication "On the Chemistry of the Hottest Stars."
ROYAL INSTITUTION, at 3.—The Relation of Geology to History: Prof. W. Boyd Dawkins, F.R.S.
SOCIETY OF ARTS (Imperial Institute), at 8.—The Cultivation and Manufacture of Rhea Fibre: Thomas Barraclough.
INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—On some Repairs to the South American Company's Cable off Cape Verde, 1893 and 1895: H. Benest. (Continuation of Discussion.)
CHEMICAL SOCIETY, at 8.—The Pasteur Memorial Lecture: Prof. P. F. Frankland, F.R.S.
CAMERA CLUB, at 8.15.—From Mont Blanc to the Matterhorn: Lamond Howie.

FRIDAY, MARCH 26.

ROYAL INSTITUTION, at 9.—Early Man in Scotland: Sir William Turner, F.R.S.
PHYSICAL SOCIETY (Finsbury Technical College), at 5.—Various Exhibitions of Experiments, &c., will be shown by Prof. Thompson and others.
INSTITUTION OF CIVIL ENGINEERS, at 8.—The Re-signalling of the Liverpool Street Terminus of the Great Eastern Railway: W. J. Griffiths.

SATURDAY, MARCH 27.

ROYAL INSTITUTION, at 3.—Electricity and Electrical Vibrations: Lord Rayleigh, F.R.S.
ROYAL BOTANIC SOCIETY, at 4.
ESSEX FIELD CLUB (at Loughton), at 6.30.—Seventeenth Annual Meeting. —Presidential Address: Field Work as Science Training: David Howard.

MONDAY, MARCH 29.

SOCIETY OF ARTS, at 4.30.—Alloys: Prof. W. Chandler Roberts-Austen, C.B., F.R.S.
SANITARY INSTITUTE, at 8.—Ventilation, Warming, and Lighting: Dr. Joseph Priestley.
INSTITUTE OF ACTUARIES, at 7.—Mortality Experience of Assured Lives and Annuitants in France: G. F. Hardy.
CAMERA CLUB, at 8.15.—Snowdon in Winter; Climbing in Dauphiné: Henry Speyer.

TUESDAY, MARCH 30.

ROYAL INSTITUTION, at 3.—Animal Electricity: Prof. A. D. Waller F.R.S.
SOCIETY OF ARTS, at 8.—Lead-work: W. R. Lethaby.
ANTHROPOLOGICAL INSTITUTE, at 8.
INSTITUTION OF CIVIL ENGINEERS, at 8.—Electric Lifts and Cranes: Henry W. Ravenshaw.
ROYAL VICTORIA HALL, at 8.30.—Quicksilver: Dr. H. Forster Morley.

WEDNESDAY, MARCH 31.

SOCIETY OF ARTS, at 8.—Cycling—Historical and Practical: George Lacy Hillier.
CHEMICAL SOCIETY, at 3.—Annua eneral Meeting.—Ballot for Election of Officers and Council.

THURSDAY, APRIL 1.

ROYAL SOCIETY, at 4.30.—The Croonian Lecture—"The Mammalian Spinal Cord as an Organ of Reflex Action"—will be delivered by Prof. C. S. Sherrington, F.R.S.
ROYAL INSTITUTION, at 3.—The Relation of Geology to History: Prof. W. Boyd Dawkins, F.R.S.
SOCIETY OF ARTS, at 4.30.—A Visit to Russian Central Asia: Michael Francis O'Dwyer.
LINNEAN SOCIETY, at 8.—On the Evolution of Oxygen from Coloured Bacteria: Dr. A. J. Ewart.—On the Germination of Spores of Agaricineæ: Miss Helen Beatrix Potter.
CHEMICAL SOCIETY, at 8.—On the Oxidation of αγ-Dimethyl-α'-Chloropyridine: E. Aston and Prof. J. Norman Collie, F.R.S.—The Composition of Cooked Fish: K. J. Williams.
CAMERA CLUB, at 8.15.—Mountain and West Coast Scenery at Home and Abroad: T. C. Porter.

FRIDAY, APRIL 2.

ROYAL INSTITUTION, at 9.—Metallic Alloys and the Theory of Solution: Charles T. Heycock, F.R.S.
GEOLOGISTS' ASSOCIATION, at 8.—The Physical History of Romney Marsh: George Dowker.—A Collection of Flint Implements from Cookham: Llewellyn Treacher.

SATURDAY, APRIL 3.

ROYAL INSTITUTION, at 3.—Electricity and Electrical Vibrations: Lord Rayleigh, F.R.S.
GEOLOGISTS' ASSOCIATION (Baker Street Station), at 1.37.—Excursion to Chesham and Cowcroft. Director: Upfield Green.

BOOKS AND SERIALS RECEIVED.

BOOKS.—Macmillan's Geography Readers, Book iii. (Macmillan).—The Dahlia: various Writers (Macmillan).—The Popular Religion and Folk-Lore of Northern India: W. Crooke, 2 Vols., new edition (A. Constable).—Dr. Nansen: the Man and his Work: F. Dolman (S.P.C.K.)—The Elements of Electro-Chemistry: Dr. R. Lüpke, translated by M. M. P. Muir (Grevel).—A Manual of Chemistry: Prof. W. A. Tilden (Churchill).—Glaciers of North America: Prof. I. C. Russell (Boston, Mass., Ginn).—The Phase Rule; W. D. Bancroft (Ithaca, New York, *Journal of Physical Chemistry*).—Elementary Text-Book of Physics: Profs. Anthony and Brackett, 8th edition (New York, Wiley; London, Chapman).—Picture Lessons in Natural History (Bacon).—Les Gaz de l'Atmosphère: H. Henriet (Paris, Gauthier Villars).—The Calculus for Engineers and Physicists: Prof. R. H. Smith (Griffin).

SERIALS.—L'Anthropologie, Tome viii. No. 1 (Paris).—American Naturalist, March (Philadelphia).

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