THURSDAY, FEBRUARY 3, 1898.

APPLIED MECHANICS, AND THE WAY TO TEACH IT.

Applied Mechanics: a Treatise for the Use of Students who have time to work Experimental, Numerical, and Graphic Exercises illustrating the Subject. By John Perry, D.Sc., F.R.S. Pp. v + 678. (London: Cassell and Co., Ltd., 1897.)

PROFESSOR PERRY'S position in the Department of Science and Art gives him so wide an influence on the teaching of applied mechanics throughout the country, that a book which expounds and exemplifies the method of teaching he approves will be received with keen interest. But the volume before us has no need of any adventitious claim on the attention of readers. Prof. Perry has the knack of throwing his personality into his books. You may not always agree with him: indeed, nothing would distress him more than to find you doing that; for what is the use of trailing a coat unless a gentleman will be so good as to tread on it? But, at any rate, you will not find him dull. He holds you alike by what he says and how he says it. You recognise in every chapter the fulness of his knowledge, the ripeness of his experience, the freshness of his methods, the individuality of his style. It is a style which some of us are too steeped in convention to enjoy without qualification. I must myself confess to a measure of distaste for the "Clarendons" which flash out every here and there over the printed page, not in headlines, but to emphasise words and phrases in the text. And the numerous "asides" about educational methods and other things are oddly placed in a treatise on applied mechanics. But the most critical reader will find his admiration compelled by the immense amount the book contains of excellent matter not found, or not readily found, elsewhere; and he will admit that the work is pre-eminently alive in every page, and that the author is speaking throughout with a real knowledge of real things.

Prof. Perry describes it as a treatise for the use of students. I should rather say for the use of teachers, and add that every teacher of mechanics should possess himself of a copy. It is certainly not for beginners. A fairly advanced student will find it very helpful, perhaps as a mine in which to dig rather than as a course to be systematically followed. To the teacher of applied mechanics it will prove invaluable, and through him its influence will, I believe, be far-reaching.

It is clear enough that Prof. Perry is addressing the teachers at least as much as the taught. Else what mean the frequent homilies on teaching, such as these?

"We believe that the principles which an engineer really recollects and keeps ready for mental use are very few. . . . We ought to teach him how to learn for himself. Any child can state Newton's second law of motion, and the other half-dozen all-important principles of mechanics, so as to get full marks in an examination paper; the engineer knows that the phenomena he deals with are exceedingly complex, and that only a long experience will enable him to utilise the so easily stated principles" (p. 2).

"The most important lesson for a beginner, however he may have studied mathematics and mechanics, and however able he may be as a mathematician, is this—that he must not go on merely assuming that he knows how to do things; he must know things by **actual trial.** . . . Teachers will notice that things requiring even a little preparation more than other things will gradually become neglected. . . . When we find our system to be going with clockwork regularity, and we feel no worry, we ought to believe that some change is necessary. If we find that the students are not absorbed in their work, we must understand that we teachers are in fault" (p. 3).

"If it is possible we try to learn all our mathematics, mechanics, physics, and chemistry from teachers who are engineers. What acquaintance with these subjects we have ought to be a real knowledge, and not the glib pretence which suffices for examinations. . . . To effect this object we must work many numerical and graphical exercises, and try to conquer our contempt for simple laboratory experiments" (p. 3).

"Our aim is to get students to think, and it is astonishing how difficult it is to effect this object. . . . In the mechanical laboratory I find that even the dullest student begins to think for himself if he is not too much spoon-fed; and if his difficulties are not cleared away by some wretched routine system of laboratory work being adopted by cheap laboratory instructors, the fundamental principles of mechanics will become part of his mental machinery" (p. 56).

In another passage the author insists, with great truth and force, on the desirability of introducing even elementary students to the fundamental notions and symbols of the calculus at the beginning of their study of applied mechanics. And in another he remarks that "Newton's method, the 'Thomson and Tait method,' is very much to be preferred to any other method of starting in the study of mechanics"; and adds, "Every engineer ought to have his T and T′ (the elementary treatise) a well-thumbed book."

Chapter xi. opens with these rather oracular sentences:

"We sometimes assume that our readers know quite well the fundamental principles of mechanics, and then again we assume that they do not. We hope that they agree with us that we are right in proceeding in this way" (p. 242).

One more passage showing the missionary spirit of the author may be quoted:

"A student who works such an exercise as this carefully is getting all sorts of **valuable notions,** not merely of mechanics but of practical mathematics. Unfortunately, twenty academic exercises can be worked out without much thought or trouble to teacher or student, and by the rules of the game this is sufficient for the passing of examinations. For the present, therefore, my advice will be followed by a few earnest students only—the men who want to know, the men who are not merely in search of examination tips, the men who find academic exercises difficult because they think about what they do" (p. 266).

Like all the rest of the book, these *obiter dicta* are full of interest and suggestiveness. With most of what they contend for the present writer heartily agrees. He is disposed, however, to believe that it is not always through excess of thought that men fail even in "academic" examinations.

One great lesson to be learnt from Prof. Perry is the value of the mechanical laboratory as part of the machinery of teaching. Not merely does he preach this in the passages quoted and in others, but the book is enriched by many examples of the experimental method, and by many illustrations of laboratory apparatus. Readers of Prof. Perry's "Practical Mechanics," of which this book may be regarded as an extension, do not need to be told that in the development of the mechanical laboratory he has done pioneer work of the most important kind. In his preface he refers very properly to the initiative taken by Sir Robert Ball in the teaching of mechanics by quantitative experiments, and he also speaks in altogether too generous terms of work in this direction recently done in the Engineering Laboratory at Cambridge. But it is to Prof. Perry himself that we owe in great measure the idea of a laboratory in which the students themselves carry out such experiments in applied mechanics, and the idea is one for which students, if not teachers, cannot be sufficiently grateful. Nothing contributes so much toward giving men a real and useful grasp of a mechanical principle than they should themselves make quantitative experiments with a piece of apparatus designed to exemplify the principle. But there must of course be some preliminary training in theory, and the work of the laboratory must be in close touch with that of the lecture-room.

In the history of Nicholas Nickleby we are told how Mr. Squeers claimed to "go upon the practical mode of teaching, the regular education system." He taught his boys to spell "winder" and then go and clean it, to spell "bottiney" and then weed the garden. This early and crude example of the laboratory method had two grave defects. The book-work was badly done; and there was no sufficient connection between it and the practical work, for it must be admitted that weeding does not help to spell, nor spelling to clean windows. Add to this that Mr. Squeers quarrelled with his demonstrator, which was impolitic, and that his boys were, in Prof. Perry's words, "too much spoon-fed," and it is not strange that the laboratory method did not commend itself in his hands.

We have changed all that, and as things are now there is perhaps a little danger of the practical work receiving even more than its due share of attention. Valuable as it undoubtedly is, the value of lectures and reading and "paper" work generally is not to be underrated. Prof. Perry does well to insist that the student shall "work many numerical and graphical exercises," as well as "make a great many quantitative laboratory experiments."

By the publication of his "Applied Mechanics" Prof. Perry has made a large addition to the debt which teachers and students of the subject already owe him.

J. A. EWING.

CHARLES CARDALE BABINGTON.

Memorials, Journal, and Botanical Correspondence of Charles Cardale Babington. Pp. xciv + 475. (Cambridge: Macmillan and Bowes, 1897.)

CHAPTERS in the history of the teaching of botany have now been written in the biographies of four Cambridge professors. In 1830 was published Gorham's "Memoirs of John and of Thomas Martyn," a book of small size; and in 1862 Jenyn's "Memoir of the Rev. J. S. Henslow," containing 278 pages. The last of this series, the volume under review, far exceeds the others in size, and contains 570 pages.

The plan of the book divides it sharply into three sections. The first of these sections is occupied by notices from various sources, mostly reprinted from other publications, and diverse in the points from which the views of the different writers are taken. We find Prof. Babington in the light of a college friend from the pen of Prof. J. E. B. Mayor, as a fellow-teacher of science from that of Prof. G. D. Liveing, as a fellow-botanist by Mr. James Britten, as an archæologist, and as a philanthropist. The second section (270 pages) consists of the journal kept by him throughout his long life, and the third section of letters written by him to various botanists. The book closes with a list of his publications, and a very complete index in two parts.

Undoubtedly the greatest interest in the volume lies in the scattered sentences, which refer to the struggle for the recognition of science as an educational subject, in which struggle Babington played no small part. From 1826 until his death in 1895 he resided in Cambridge; and one may remind the reader what an immense change has taken place since the first date, when the Elizabethan statutes were still in force. The early teaching of botany in Cambridge was intermittent. Richard Bradley, professor from 1724 to 1733, seems never to have lectured; John Martyn, his successor, lectured from 1727 to 1734, and Thomas Martyn, who became professor in 1762, lectured for thirty years. In 1825 J. S. Henslow's teaching commenced, and we are told that for seven years his class numbered sixty to eighty. The clearness and charm of Henslow's lectures attracted many of the older members of the University to listen to him, and among these sat for six nearly consecutive years young Babington. After this we learn that the numbers attending the class fell. In 1861 there were no lectures. Babington, meanwhile being elected professor, begins to lecture in 1862, and in 1864 (p. 359) has a class of thirty-five to forty-five students, in 1865 (p. 362) of forty, in 1866 (p. 205) of about forty-five. Such references as these, scattered sometimes in letters, sometimes in his journal, will serve as grist to the mill of a historian wishing to write an account of science in England. The story of Babington's influence for the promotion of natural history, especially in the years before he became professor, is admirably told in Prof. Liveing's memoir on p. lvii.

A regular attendant at the meetings of the British Association, he was one of the founders of the Red Lion Club, a club formed by a little knot of kindred spirits who dined together during the meeting. On p. 85, the founding is thus noticed: "1839. Aug. 29. Yesterday and to-day we formed a private dinner-party at the 'Red Lion' inn (Birmingham), with Dr. Macartney in the chair." Frequent mention of the "Red Lions" occurs in the following pages.

In his letters to J. H. Balfour, A. G. More, and others upon scientific publications, we find him (p. 302) ill-satisfied with the *Phytologist*, and (pp. 288, 291, 306, 312, &c.) very solicitous for the good of Henfrey's *Botanical Gazette* and the *Transactions* of the Edinburgh Botanical Society.

So much for the purely historic side of the book. There occur in the first pages of the journal notes upon insects, and here and there throughout archæological jottings; but the greater part, as one would expect, concerns British plants. The letters are all botanical, and usually express his opinion upon some difficult plant; the journal contains accounts of his "finds" on the excursions which he made in all parts of the British Isles, in the Channel Isles, and in Iceland. Much, indeed, is matter of greater interest to the compiler of a local flora than to the general reader. Yet the history of the changes of opinion upon critical plants, and the notices of the discoveries of forms new to our islands, will appeal to many British field-botanists. To sift the synonymy it is necessary to turn to the first index, where, with the exception of the brambles, the nomenclature of the last edition of Babington's "Manual of British Plants" is followed. One could wish that this sifting of the names had been done in footnotes, in which way it would catch the reader's eye more readily. The index tells us that, on p. 169, *Potamogeton flabellatus* stands for *P. decipiens*, and that *Euphorbia pilosa* appears under five names. Such instances may be here quoted with the remark that reference to this index is very necessary in using the book.

Lastly, in spite of its many pages, the volume is light; the printing is excellent, and the portrait at the commencement a very true likeness. A second portrait, taken at the age of seventeen, occurs at the commencement of the second part, and a pedigree-table occupies a pocket at the end of the book. I. H. B.

DIAMONDS.

Papers and Notes on the Genesis and Matrix of the Diamond. By the late Prof. Henry Carvill Lewis, M.A., F.R.S. Edited from his unpublished MSS. by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S. Pp. 69, with 2 plates and 35 woodcuts. (London: Longmans, Green, and Co., 1897.)

Diamonds. A Lecture delivered at the Royal Institution, Friday, June 11, 1897. By William Crookes, Esq., F.R.S., M.R.I. Pp. 25, with 39 photographs. (*Journal* of the Royal Institution of Great Britain, 1897.)

AMONG the subjects which attracted the attention of the able and versatile geologist of Philadelphia—whose early death was so deeply mourned both in this country and the United States—was that of the mode of occurrence and the origin of the diamond. At the meeting of the British Association at Birmingham in 1886, Prof. Carvill Lewis read a short paper "On a Diamond-bearing Peridotite and on the History of the Diamond"; and in the following year he communicated to the Association meeting at Manchester a much longer and more elaborate paper on the same subject, which was entitled "The Matrix of the Diamond." It was well known to Carvill Lewis's numerous scientific friends in this country that he had collected much valuable evidence concerning the association of diamonds with peridotite and serpentine in all parts of the world, and had arrived at certain very definite views concerning the constant association of the crystalline form of carbon with the ultrabasic rocks.

Geologists are indebted to Prof. Carvill Lewis's widow for the publication of the work, the title of which stands first at the head of this article, in which these two valuable papers have been printed in full, and to Profs. Bonney and Rosenbusch for the painstaking care and sound judgment with which they have been edited. In the opinion of neither the editor himself nor of Prof. Rosenbusch, were the fragmentary notes on the wider and more theoretical questions connected with the origin of the diamond in such a state as would warrant their publication; but Prof. Bonney has been able to add a memoir describing the occurrence of rocks similar to that found in the diamond mines of South Africa—to which Carvill Lewis gave the name of "Kimberlite"—from two localities in the United States. These descriptions are based on information supplied by Mr. J. S. Diller, of the United States Geological Survey, and by the late Prof. G. Huntingdon Williams, of Baltimore, in addition to the notes and specimens collected by the late Prof. Carvill Lewis himself. Geologists now possess, in the work before us, the most complete and satisfactory account of the curious rock in which the diamonds of South Africa are embedded; equal care being devoted to the microscopic structure of the rock, and to the identification of the various minerals present in it.

Turning our attention from the papers of Carvill Lewis to the lecture of Sir William Crookes, it is impossible to avoid being struck with the great advances which have been made, during the last ten years, in our knowledge of the properties and mode of occurrence of that most wonderful and interesting of all minerals—the diamond.

The first part of the lecture of Sir William Crookes is occupied with a popular account of the diamond mines of South Africa and the manner in which they are worked. The author having recently returned from the district, where special facilities had been afforded him for scientific observation, is able to supply a very lively description of the country and its inhabitants, as well as of the operations by which the diamonds are obtained. The reproduction of the photographs with which the lecture was illustrated adds greatly to the value of the pamphlet.

Concerning the properties of the gem, Sir William Crookes is able to supply much valuable information, recently obtained, concerning the intimate relations between diamond and graphite, and the conversion of one material into the other, and also on the action of the Röntgen rays upon the diamond. As a means of distinguishing true diamonds from all kinds of paste imitations, the Röntgen rays appear to be invaluable, for we have here a test which can be applied to cut and mounted materials without any risk of injury to them.

In the decade which has elapsed between the reading of the two scientific communications which we have placed at the head of this notice, the discoveries concerning the mode of occurrence and the artificial formation of the diamond have been of especial importance—and they are admirably summarised by Sir William Crookes in his lecture.

In 1884 Erofeyev and Lachinov showed that an iron meteorite contained diamonds, and this fact was more recently confirmed by Foote's discovery of diamonds in the Cañon Diablo meteorite, and by that of Weinschenk in the meteorite of Ava. Cliftonite, a form of carbon in cubical crystals, detected by Mr. Fletcher in the meteorite of Youndegin in West Australia, may not improbably be regarded as a pseudomorph in graphite after the diamond.

Finally, Moissan's preparation of diamonds by crystallisation from molten iron has at last solved the long-standing problem of the artificial formation of the mineral.

Sir William Crookes suggests both a deep-seated terrestrial, and a meteoric origin as possible for the diamonds found upon our globe—in both cases the agency of iron as the crystallising medium being invoked. It must not be forgotten, however, that the same mineral species has often originated in many different ways, and it is by no means certain that nature in her laboratories—provided as they are with such abundant resources—has been compelled to resort to precisely the same expedients as we have been led to employ in our experimental researches. J. W. J.

OUR BOOK SHELF.

The Constitution and Functions of Gases. Part iii. By Severinus J. Corrigan. Pp. 179. (St. Paul: Pioneer Press Company, 1897.)

THIS volume is a continuation of the "Constitution and Functions of Gases"—the first two parts of which were reviewed in these columns last year—and deals with the applications of the author's theory to questions of astronomy, treating especially with the genesis and development of the solar system, the age of the sun and the earth and the other planets, and the consideration of the earth from its geological aspect.

It may be remembered that the author in the first part of his treatise expounded a new theory of gases, where, instead of the irregular movements of colliding molecules as developed in the theory of Clausius and Maxwell, the molecule is supposed to remain stationary as a whole, but is made up of a large number of electric or magnetic doublets which revolve in approximately circular orbits with enormous velocities. In this way many of the properties of gases can be readily explained, and the solutions of many interesting problems attempted which, in some cases, agree fairly accurately with experimental results. The theory was ingeniously developed to do away with the necessity of an ether for the transmission of light vibrations through space, by substituting for it a gas of extreme tenuity.

By utilising the general ideas of the nebular hypothesis of Laplace, and by applying the equations obtained in the first treatise, the author proceeds to investigate the genesis and development of the solar system, to determine the ages and temperatures of the planets, as well as a multitude of other important facts, which, if they could only be demonstrated, would place the author on a pedestal by the side of Newton as the greatest astronomer of the age. The fertility of resource of the author in developing his ideas is astonishing, and though at all times the theories are intended to be primarily based on known experimental data, this basis is in many cases so slight and uncertain, and the assumptions so numerous, that the results must be looked upon as mere speculations. The author is equally at home discussing the cause of the Noachian deluge, the nature of vegetation on the planet Mars, and the cause and origin of X-rays.

In the treatment of the earth, the duration of every geological epoch and its cause is determined. The great glacial period is discussed, and, according to the author's views, must be ascribed to the varying intensity of the sun's radiation in past ages.

It is impossible in this short space to enumerate a tithe of the wonderful results that the author obtains; but though there is much that is purely visionary, occasionally some very interesting suggestions are advanced which bear the stamp of probability. The book is written from a scientific rather than a popular point of view, and is chiefly of interest as an example of how an ingenious mind can build up a large and comprehensive theory on very slight foundations. E. R.

A Run round the Empire; being the Log of Two Young People who Circumnavigated the Globe. Written out by their father, Alex. Hill, M.A., M.D., Master of Downing College, and Vice-Chancellor of the University of Cambridge. With 42 illustrations. Pp. viii + 286. (London: Swan Sonnenschein and Co., Ltd., 1897.)

THE Master of Downing jokingly lays claim in his preface to the invention of a new system of education—by taking children for a voyage round the world "before the faculty of observation has been stifled by the study of dead languages, mathematics and other abstract subjects, which have no counterpart in our physical environment." The stifling of the faculty of observation is, one must sorrowfully admit, too often a result of studies conducted in the manner of English schools; but the method of education by travel is surely at least as old as the days of the obsolete Grand Tour; and educational journeys for children form part of the routine of many continental schools.

The short record of a family trip round the world is of a character with which the public is familiar: notes of the trivial incidents of life on board ship, little bits of history, occasional touches of moralising, and vivid impressions of what must have been a very enjoyable as well as a most instructive holiday. The route led by Gibraltar and Naples to Port Said, thence to Colombo, whence a considerable tour in Ceylon was made, on to Australia, Tasmania, New Zealand, Samoa, the Sandwich Islands, and home by the Canadian Pacific Railway and the Atlantic. The young people are indeed to be envied who have so magnificent an opportunity of educating themselves by seeing the world while still unstifled by scholastic cram.

A few slips are not to be wondered at. It is remarked of the Suez Canal that "larger undertakings of the same kind have been carried out since," the diversity in the use of Tacoma and Rainier (not *Ranier* as printed), as names of a mountain, is not correctly described; Morley is transposed to the wrong side of the Rocky Mountains, and Labrador and Newfoundland change places on the Strait of Belleisle. There is, unfortunately, no map; but if read with an atlas, this pleasantly written book should prove a valuable supplement to more formal geographies. H. R. M.

Wild Flowers, and other Poems. By James Rigg. Pp. 294. (Paisley and London: Gardner, 1897.)

IT is not within our province to express an opinion on the metrical merits of this volume. The author is evidently an ardent lover of nature, and of a poetic disposition. We have learnt, by sad experience, not to expect too much scientific accuracy from writers of verse; and the volume before us is not alone in its offences. Still, it does seem strange that the author should not have got some botanist friend to look over his proof-sheets; for by so doing he would have learnt that *Vaccinium europæa* (*sic*) is not the Latin name of the "blaeberry" (*sic*), nor *Stellaria minor* of the chickweed, nor *Pinus borealis* of the Scotch pine. The Latin names are constantly misspelt.

LETTERS TO THE EDITOR

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

The Mathematics used in Connection with Physics.

IT may seem ungracious for an author to reply to a review containing so many kind expressions as the one with which Prof. Ayrton has honoured my book on "Electricity and Magnetism" in your issue of November 18; nevertheless, I trust that you will permit me to make a few explanations and even corrections, if the word is permissible.

Since the reviewer states that "it is not quite obvious what is the object of giving" the mathematical introduction, I may state rather more fully than I was able to do in my rather long preface for what class the book was intended. The only class of students with which I come in contact at Clark University is composed of so-called "graduate students," that is men who have taken the bachelor's degree at a college, and are intending to undertake research. It is not generally known that this university was founded for the express purpose of encouraging such men, and consequently, alone among American universities (with the exception of the Catholic University in Washington), has no other students. The same class of students is, however, to be found in large numbers at all the larger universities, so that what I have to say is of general application. These students come to us from all parts of the United States and Canada, and I have had two or three from Europe, so that they have had very various training. They have been at college for four years or more, and have generally taught for awhile themselves. They may have studied the calculus for two years or less, so that although they all know "the meaning of a differential coefficient," and are able to integrate and differentiate with fluency, they are not Cambridge wranglers, and their ideas regarding continuity, convergence of series, definite integrals, and the like, are generally decidedly hazy, while they probably have no acquaintance with the calculus of variations, the theory of functions, and more difficult subjects. It was in order to have some of these matters of most frequent occurrence in a convenient place to refer to that I prefixed the introduction, not with the idea of giving a complete treatment, but to show the student some of the things he should certainly get up, and by means of foot-notes to show him where he could go further. In the numerous kind letters that I have received from teachers of physics in this country, I think all have especially commended the idea of this introduction. At any rate, I had so good an example as Maxwell, who thought it worth while to put a mathematical chapter at the beginning.

With regard to the suggestion that "possibly the students of Clark University, when listening to such lectures as are given in this treatise, have the physical meanings of the various mathematical processes explained to them," which the reviewer intimates would be desirable, I will say that these students have worked generally two years or more in a laboratory, making the usual measurements, and that it is hardly necessary to explain to them what a magnet is, or how a galvanometer is constructed. In order to cover the ground, it was necessary to condense, as the book was already larger than I intended.

Prof. Ayrton asks, "Is it correct to say that 'following the usage of the majority of writers, we shall denote' Laplace's operator (I forbear to write the signs of variation, which the printer has put for round *d*'s) 'by Δ,' seeing that many writers, including Thomson and Tait, use ∇^2 and Maxwell $-\nabla^2$?"

I was rather careful to find this out when writing the passage, and to quote only from the works which I have at hand. I may state that to the two authors named using ∇^2 might have been added the names of Lamb, Minchin, Routh, Basset, and Rayleigh, while the notation Δ is used by Mascart and Joubert, Duhem, Kirchhoff, F. Neumann, C. Neumann, Mathieu, Boltzmann, Helmholtz, Clausius, Drude, Picard, Jordan, Hertz, Klein, and by Poincaré, who calls it *la notation habituelle.* The notation Δ_2 is used by Lamé, Somoff, Boussinesq and Voigt, while Betti writes Δ^2. I did not say "the majority of English writers."

That Gauss's theorem "would be perfectly useless if gravitational, electric, and magnetic forces did not vary as the inverse square," I can hardly agree, seeing that it would be just as true, and would have applications to the flow of heat, hydrokinematics, geometry, and the theory of functions. It is just as well for electricians to remember that the world was not made for them alone.

The reviewer is certainly labouring under a misapprehension when he says "The statement of the general problem of electrostatics, as given at the beginning of § 135, is insufficient since, as pointed out, any number of solutions could be given to it." On the contrary it is explicitly pointed out, at the top of page 265, that there is but one solution, which is completely determined. It is comforting, however, to learn that "the method, however, which is indicated for the solution of the problem is correct, and leads in a neat way to the conception of coefficients of induction"; though the credit can hardly be taken by the present writer, the method being taken from Betti's well-known treatise given among the list of works made use of.

With regard to d'Alembert's principle, I will only say that for the purpose for which it is introduced, namely the deduction of the equations of motion of a system of particles, Hamilton's principle, &c., it seems to me that it makes no difference whether the internal forces appear or not. In any case I have said more about the principle than Kirchhoff, who merely writes down the formula, and Appell, who only says *qui signifie que, pour un déplacement virtuel arbitraire imprimé au point à l'instant, la somme des travaux virtuels de la force d'inertie et des forces reellement appliquées au point est nulle.* Practically the same statement is made by Thomson and Tait, and repeated by Tait in his small book on dynamics.

It seems to me that Green's function is hardly "divorced from its physical application" when it is stated that Green introduced it to solve certain problems in electrostatics. Its physical meaning as the potential of a certain electrification is also given.

The reviewer states that the analogy between electrical and magnetic phenomena is carried too far when the same letter is used for specific inductive capacity on some pages and for magnetic permeability on others. Also that "the beginner might expect to find μ instead of which he finds ϵ; the meaning, however, of this ϵ does not seem to be given." As a matter of fact, it is explicitly stated that μ is used where it refers indifferently to *either* the electric or magnetic quantity, while the meaning of ϵ is given in the next line to the one in which it first occurs, on page 509.

With regard to my "poking fun" at anything or anybody, I beg leave to assure Prof. Ayrton that his statement that "the fun is not intentional on the part of the author" is due to a misapprehension.

Finally, to the suggestion that "a course of 'Lectures on Mathematical Physics' may fitly contain explanations of the physical interpretations of the equations developed without running the risk of appearing to pander to the electrical contractor," it may be replied that much depends upon the point of view. To me the steam-engine or the dynamo are interesting as examples in thermodynamics or induction. I am well aware that this is not the usual view, nor do I suppose it ever will be. I need not conceal the fact that none of my students have ever become engineers. We have an excellent engineering school in our city (which, by the way, is Worcester, and not Webster, as your heading makes it), and we have no reason to try to duplicate the work done there. Some of its graduates have come to us, and have done good work in physics or mathematics, but they have dropped engineering. I say this, not with the slightest wish to disparage engineering or engineers, but to emphasise the fact that there are others to be considered as well.

A. G. WEBSTER.

Clark University, Worcester, Mass., December 15, 1897.

A New Single Picture Pseudoscope.

THE principle of the stereoscope is so well known that it is unnecessary to point out that two dissimilar pictures are required of a special character in order to produce the stereoscopic or solid effect. Consequently it may be imagined that to obtain a stereoscopic effect with a single picture is an impossibility.

It is clear that if the possibility exists a *true* stereoscopic combination would not result, but one which would approximate more or less closely to the truth.

Many devices have been brought out in the hope of giving a single picture a solid appearance, such for instance as a large convex lens. All these devices, however, fail to give the desired result. The illusion, so far as it goes, is simply a distortion of the original picture.

The nearest approach to the production of the stereoscopic effect from a single picture is by photographing the illustration with its plane inclined at an angle of the optic axis of the lens, first in one direction, and then again in the opposite direction; in which manner two dissimilar pictures are produced, which can be viewed with an ordinary stereoscope, and the result is by no means unsatisfactory. The process, however, is inconvenient.

For a long time past the writer has been experimenting with stereoscopy, and amongst other objects one has been to secure a stereoscopic effect with a single picture. This he has now succeeded in attaining in a comparatively simple manner.

If a stereoscopic slide is examined it will be found that each picture is compressed, so to speak, on the inner side, which is equivalent to saying that the central line of any one picture is shifted from the centre inwards, thus expanding one half of the picture and compressing the other half.

It therefore appeared to the writer that, if by some means a single picture could be made to give two images, each one compressed in a suitable manner and then viewed with the ordinary stereoscopic lenses, the solid effect should be produced, and such is the case.

The method is as follows:—A large deep cylindrical lens is taken and cut in two along the line where the lens is thinnest. Thus two wedges are produced, each having one side curved and the other side flat. If these two pieces are placed together, with the thick portions towards one another, and held at a short distance over any picture, the eyes will perceive an image of the illustration in each lens, and the pictures will be compressed in the manner already referred to.

All that is now necessary is to view these two images with ordinary stereoscopic lenses. One picture will result, as solid in appearance as if the ordinary stereo slide had been employed.

The apparatus will be found of considerable use for looking at small photographic portraits, landscapes, &c., as well as engravings. The result is very pretty.

Naturally one class of picture must suffer under the operation; but as these are comparatively rare, there is an extended use for the instrument, which is called the Pseudoscope.

The pictures unsuitable are those which represent an object when placed very near the eyes, since the image produced by solid objects in each eye in such cases differ greatly; but this difference in the image is comparatively small after a distance of, say, 15 to 20 feet.

DAVID SALOMONS.

MAGNETIC OBSERVATIONS IN THE HARZ MOUNTAINS.

DR. ESCHENHAGEN has made an interesting series of magnetic observations at forty-two stations in the Harz Mountains.

The uncertainty of a declination observation was about 1′, of the dip with two needles about 1″·2, and the probable error of the horizontal force was about ± 0·00010 C.G.S. units. As it was intended to compare the results with those of a survey of the same district in which the deviations of the plumb-line were determined, the stations were selected with reference to this fact, and also to the geological conformation of the country.

The magnetic disturbances and disturbing forces were determined by a method essentially similar to that employed in the survey of the United Kingdom. The results were not very definite in the northern part of the district examined, but a clearly marked "ridge-line," or locus of attraction on the north-pole of the magnet, was discovered in the south. In one part of this the vertical disturbing force nearly reached 0·00400 C.G.S. units. There are few stations in England and Wales where the disturbance is as large as this, though at Stratford-on-Avon it is exceeded by 25 per cent. At some places purely local attractions of very much larger magnitude were detected. Thus, on the Leistklippe the dip was altered by 11′, and the vertical disturbing force was 0·04224 C.G.S., or one-tenth of the whole vertical force. No such remarkable effects were observed near the principal granitic masses, such as the Brocken.

The fact that the magnetic ridge-line lies to the south of these is explained by the hypothesis that the granitic mass, of which the Brocken is the upper end, extends underground in a direction inclined to the vertical, and running from the surface towards the south. This view is, in the opinion of Dr. Eschenhagen, consistent with the geological facts. As, however, the granite is but slightly magnetic, it is also necessary to suppose that the heavier, more magnetic granite, lies deep, and is only brought near to the surface at a few points such as those at which the greatest local disturbances occur.

The local deviations of the plumb-line were deduced from observations made by the Royal Prussian Geodetic Institute. To the north of the mountains the plumb-line is deflected to the south; from the south an attraction towards the north is detected. The line of no deviation is to the south of the Brocken, and runs nearly parallel to, but about 10-12 km. north of, the magnetic ridge-line.

The remarkable result is therefore attained that (1) geological evidence, (2) the magnetic needle, and (3) the plumb-line all point to the conclusion that the heavier rocks lie some distance to the south of the chief visible masses of granite.

Dr. Eschenhagen is careful to point out that it is unlikely that a similar agreement would be attained in every place where similar experiments might be carried out, as the rocks of greatest density are not necessarily magnetic. None the less, his observations make it probable that the magnet, the pendulum and the plumb-line may add much to our knowledge of the details of the constitution of the crust of the earth; and his survey of the Harz Mountains is one of the most striking attempts which have yet been made to combine the results of magnetic and geodetic surveys.

A. W. R.

THE JOURNAL OF ANATOMY AND PHYSIOLOGY.

NEARLY nine years ago, on the occasion of the coming of age of the above-named Journal, we directed attention (NATURE, vol. xxxvii. p. 441) to its association, as a medium of publication, with the then newly established "Anatomical Society of Great Britain and Ireland." Since that time the connection between the two has been maintained, much to the advantage of the Journal, for not only have the "Proceedings" of the Society materially improved and increased in bulk and importance, but many of the leading papers which have appeared in the body of the Journal have reached it through the mediation of the Society, while in the latter's annual reports of its "Committee of Collective Investigation" there have been contributed results of great service alike to the scientific and surgical anatomist. Owing to the death of the founder of the Journal and main supporter during its earlier years, the beloved and universally respected Sir G. Humphry, a reconstitution of the staff of its "conductors" was recently decided upon, and with the issue for October last a new series was accordingly commenced, Profs. Sir W. Turner and J. G. McKendrick, so long associated with its success, announcing that for the future they would be assisted by Profs. D. J. Cunningham, A. Macalister, and G. D. Thane. There has just reached us the second (January) part which has appeared under these new auspices. During the years which have elapsed since our previous notice was written, three of the five present conductors of the Journal have been presidents of the Anatomical Society, while Prof. Macalister, having been on November 26 elected to that office, now combines the two functions. And during the same period the Anatomical Society undertook the preparation, and the conductors of the Journal the publication, of a couple of analytical indexes to its first thirty volumes, entrusting the task to Mr. A. W. Kappel, the efficient librarian of the Linnean Society of London, who has carried it out with conspicuous success. Society and Journal have thus become more and more closely connected, and to what extent may be gathered from the fact that of the thirty-three papers which make up the body of the first two parts of the new series, fifteen were read at the Society's meetings. Of these, the papers by Prof. D. J. Cunningham and Dr. Elliot Smith on the anatomy of the cerebral cortex and fornix stand pre-eminent, as important communications by leading investigators, who with Symington and others have kept this rapidly developing department of laborious research fully abreast of the continental standard set by von Kölliker, Edinger, Ziehen, and those who have followed in the wake of Golgi and y Cajal. Dr. Elliot Smith's monographs are indispensable to the comparative neurologist, and they amply fulfil the expectation raised by his early investigations in Australia, and justify the graceful comment paid by Sir W. Turner at the summer meeting of the Anatomical Society, held in Dublin in June last, at which one was hurriedly read. Beyond this, the second issue in the new series of the Journal is especially noteworthy for a paper by Prof. Symington upon the thymus gland in Marsupials, about which little indeed is known, and for the first part of one by Dr. D. A. Welsh upon the parathyroid glands, both being exceedingly welcome now that current work upon the ductless- and blood-glands is revolutionising our knowledge and conceptions of these remarkable organs. Noteworthy also is the completion in the same part of a lengthy treatise by Dr. W. McDougall upon a theory of muscular contraction, since by comparison with a remarkable paper by Prof. Rutherford, side by side with which it has for the most part appeared, it opens up fresh themes for controversy upon this interminable topic, which show at least that the last word has not been written concerning it, and that there is sore need of its attack on other than morphological lines. Returning to the first part, we note a paper by Mr. F. J. Cole on the urinogenital system of the male guinea-pig, which for thoroughness of investigation and exhaustive literary research is worthy the standard he adopted in a recent paper on the nervous system of the chimæroids, and the very interesting announcement by Prof. Disse, of Marburg, that the olfactory nerve fibres in the chick arise from cells situated in the epithelium of the olfactory pit, and by Prof. Leboucq, of Ghent, that in the full-grown fœtus of a *Vespertilio* the fourth digit of the manus is tetraphalangeate.

Of the remaining papers one only calls for special comment, viz. that "On the anatomy of *Macropus rufus*," by Prof. Bertram Windle and Mr. F. G. Parsons, since it reveals some strange contradictions both within its own limits and by comparison with the afore-mentioned paper by Symington. It contains a great deal by way of careful and detailed anatomical description which, in correlation with similar papers which its authors have published elsewhere, ought to be of service for reference. Under the heading "Digestive System," however, they have described and figured the liver on one page as destitute of a left central lobe, the lobe present on that side being regarded as a left lateral, while on the very next page the latter is said to be absent. Their first conclusion is based on the relationships of the falciform ligament, unquestionably the only structure of real morphological value for the purpose, and they introduce some pertinent criticism of the methods of other anatomists. All the more remarkable, therefore, their account of certain glands, as said to exist in the "fœtus" (strictly a pouch specimen). On p 132 there is given a processed illustration, little resembling anything in nature, with an accompanying description of glandular structures regarded as "sublingual" and "extra-salivary." That the former are merely the ordinary sub-maxillary glands, there seems no manner of doubt. Concerning the latter, we are assured that "histological examination proved that they were salivary in nature." Great though the backward extension of the salivary glands in some mammals, nothing at all approximate to the remarkable condition here alleged has hitherto been observed, and sufficient is recorded by the authors of the detailed relationships of the so-called "extra salivary" glands to render it tolerably certain that they are but cervical thymus, a conclusion borne out by the authors' confession that they "did not succeed in tracing the termination of their ducts," and by comparison of the descriptions and figures of the neck glands in *M. giganteus* given by Symington, as he justly points out (p. 283). The brief statement which we cite concerning the histology of these glands is wholly insufficient. If they be really salivary, for so extraordinary a condition at least a figure and full details of microscopic sections should have been furnished in absolute proof. While we await with interest further investigation as to the real nature of these, we cannot allow the statements concerning the liver to pass without further comment. Leading anatomical journals other than that now under review might be cited in which inaccuracies unpardonable at times appear. Authors, when inexperienced, will write extraordinary things; experienced authors still more extraordinary. And surely the rendering of Nathusius's well-known name (p. xxix. Suppl.) as "Nathenius," is a matter which the editors, if not the author, should not have allowed to pass. The first two parts of the new issue of the Journal, as a whole admirable and encouraging, give excellent promise for the future, if only the conductors will declare themselves responsible editors and a proper coordination between authors and editors be assured.

GEOLOGY AND SANITARY SCIENCE.[1]

THIS memoir is a new departure on the part of the Geological Survey, being devoted only to applied geology, to questions which have for a long time caused the flow of a steady stream of inquirers to Jermyn Street. It shows how useful is some knowledge of geology to the proper understanding of many matters that are ever cropping up, privately in such things as the choice of a site for a dwelling, and publicly in such as water-supply for a district.

The extent of the district treated is shown by the excellent chromolithographed map, and may be understood from the following list of the border-towns, with London in the centre:—Chesham, Amersham, Beaconsfield, Windsor, Guildford, Dorking, Reigate, Sevenoaks, Gravesend, Billericay, Chipping Ongar, Epping and St. Albans. The colours differ largely from those used on the Survey maps, and the map differs from the lately issued Index Map (on the same scale, four miles to an inch) in showing the various divisions of the Drift; so that there are thirteen colours, besides a blank for Alluvium.

A short description is given of the general structure of the London Basin, with parts of its borders, and then (pp. 7–25) a more detailed account of the beds dealt with, from the Made Ground of London down to the Hastings Beds of the Weald; thus going a little beyond the area of the map, on the south, in which the last are not shown. These are grouped, not in the usual geologic way, but according to character; all gravels and sands being under one heading, all clays under another, with an intervening "mixed sub-soils" for those divisions that decline to be distinctly one thing or another. Under each of the many sub-headings

[1] "Memoirs of the Geological Survey. Soils and Sub-soils from a Sanitary Point of View; with especial reference to London and its Neighbourhood." By H. B. Woodward. Large 8vo. Pp. vi + 58; folding geologic map (13 colours).

the sanitary aspects of the beds are noticed. In the map the index of colours is grouped in three series, clayey, gravelly and sandy, with Alluvium detached at the top, and Chalk at the bottom.

In the rest of the memoir a purely sanitary arrangement is adopted, under four heads, the first being that of the sub-soil with reference to sites for houses (pp. 27–32). The way in which not only the character of the beds, but also their thickness, position, and mutual relations affect the suitability of ground for building-purposes is enforced, and the causes of contamination of porous sub-soils are discussed : even gardens are not neglected.

Secondly, water-supply and drainage are treated (pp. 33-39). After noticing the supply of London, the question of rural water-supply is taken, the causes of contamination of shallow wells and the danger of "dead wells," used as receptacles for sewage, &c., being described. Then we have sanitary considerations in regard to the situation and surroundings of houses (pp. 40–45), under which head subjects other than geologic are referred to, such as surface-drainage, fog, sunshine, rain, wind, floods.

The troublesome question of cemeteries fittingly comes last (pp. 46-48), and the author concludes that "an isolated tract of elevated ground, where sands and sandy loams, or sandy and loamy gravel, of considerable thickness, rest on clay also of considerable thickness, offers the most desirable site," which, however, is qualified by the addition that "probably a sandy and calcareous loam is the best material for a graveyard." However, the difficulty is to get such desirable sites! The fitting conclusion is a list of the cemeteries in and near London, with the beds on which they are placed, by means of which people who are thoughtful of their latter end can select the geologic formation in which they would like to be buried.

The long index (ten pages), is really more than an index. It is not limited to giving the pages of reference ; but also notes, by figures in another type, the height of the various places above Ordnance datum, and, by means of letters, the beds on which the places are—an ingenious and useful novelty.

Although this is the first Geological Survey memoir devoted to sanitary matters, it should be remembered that stores of information that is useful from a sanitary point of view are to be found in many of those memoirs, especially as regards wells and water-supply.

This work should have a ready sale, as it is written in such a way as to be useful to the ordinary inquirer, and of interest to any intelligent reader ; but the price (2*s*. 6*d*.) is rather high, presumably on account of the map. It is to be hoped that the author may ere long have to prepare a new and enlarged edition, and that the success of the present venture may lead to other work of the same sort being undertaken.

W. WHITAKER.

PROFS. C. RUNGE AND F. PASCHEN'S RESEARCHES ON THE SPECTRA OF OXYGEN, SULPHUR, AND SELENIUM.[1]

IN the above paper Profs. Runge and Paschen have extended their important investigations to the spectra of oxygen, sulphur and selenium, and have discovered in the low temperature spectra of these elements a number of series which are very similar to those previously found for other elements. The principal characteristics of these series are too well known to need any further explanation ; they may be represented by Kayser and Runge's original formula,

$$N = A - \frac{B}{n^2} - \frac{C}{n^4},$$

where N is the wave frequency and n takes up the values 3, 4, 5 . . . for the different lines of the same series. In the present cases n^4 may be with advantage replaced by n^3. We may with equal accuracy take Rydberg's formula,

$$N = A - B(n + \mu)^{-2},$$

where A, B, μ are the three constants. In the spectrum of oxygen which goes by the name of "compound line spectrum," and which Piazzi Smyth has shown to be chiefly made up of close triplets, Runge and Paschen show that these triplets arrange themselves in two series, having approximately the same convergence frequency. The difference in the curve numbers of the components being the same for each triplet, they have all the characteristics of the "Nebenserien" or "associated series," as I propose to call them, because they always occur in groups of two. The formulæ for the strongest lines of the triplets in Rydberg's form is

1st assoc. series : $23207.96 - 110396 (n - 0{\cdot}02148)^{-2}$
2nd ,, ,, $23200,63 - 109011 (n - 0{\cdot}24127)^{-2}$

Rydberg has given a law according to which the principal series may be calculated from the associated series, with sufficient approximation to identify the lines belonging to it in the present instance. Only two triplets belonging to it have been found ; the first in the extreme red has a wave-length of 7776 for its strongest lines, and the second, photographed by Runge and Paschen for the first time, has a wave-length 3948. In addition to the triplets, the authors have discovered a number of doublets which can also be grouped into two associated series, having the equations

$$21205,56 - 109366,7 (n - 0{\cdot}16191)^{-2}$$
$$21211,11 - 110346,7 (n - 0{\cdot}01093)^{-2}$$

and the principal series belonging to this group is probably represented by two lines at wave-lengths 4368, 5, and 3692, 6, the former being one of the strongest lines of the compound line spectrum.

The result of this investigation of the oxygen spectrum is, that it shows two sets of associated series similar to that found in the case of helium, and that therefore the spectroscopic evidence that helium is a mixture of two gases no longer holds. There is very little doubt that the oxygen spectrum is represented among the Fraunhofer lines ; almost conclusive evidence in favour of this being given by the first triplet of the principal series, which falls at 7776 in a portion of the solar spectrum which is comparatively free from lines. The beautiful photographs of Higg show at this place a triplet the components of which have exactly the right difference in frequency.

Profs. Runge and Paschen also investigated the spectra of sulphur and selenium, and discovered spectra which correspond to the compound line spectrum of oxygen. The spectra consist chiefly of triplets which may be arranged in a group of associated series ; and there are also indications of the existence of two principal series in each case. The authors apparently considered these spectra as due to the elements, but they have only been able to obtain them in the presence of oxygen. Further investigation is therefore required to show that they are not really oxide spectra. Should this prove to be the case it would be a matter of some importance and great interest, for it would show that we must consider the compound line spectrum of oxygen as due to a compound molecule, an "oxide of oxygen" similar in constitution to the oxides of sulphur and selenium which give the analogous spectra.

In conclusion, I may add a few remarks as to the relative merits of Rydberg's and Kayser and Runge's equations. The greater simplicity in form of

$$N = A - \frac{B}{n^2} - \frac{C}{n^4}$$

adopted by Kayser and Runge, and the ease with which the constants may be calculated would, independently of

[1] *Wiedemann's Annalen*, vol. lxi. p. 641.

other considerations, lead us to give the preference to this form. The advantage is not, however, great, and disappears when we have to distinguish cases where we must substitute n^3 for n^4. The reason why I prefer Rydberg's form at present lies in the fact that it adapts itself better to bring out the regularities as well as the irregularities of distribution of the lines independently of any special form of equation. To show this we may write Rydberg's equation in the form

$$\frac{n+\mu}{\sqrt{B}} = \frac{1}{\sqrt{A-N}}.$$

The convergence frequency, A, may be determined by some graphical process if a sufficient number of lines have been observed, and the law of formation of a spectroscopic series may therefore be expressed as follows:

The inverse square roots of the difference between the convergence frequency and the frequency of successive lines are very approximately in arithmetical progression. If we wish to determine how far any series conforms to this law, we may in the first place calculate the right-hand side of the above expression with some approximate value of A. Systematic deviations from arithmetical progression may then be corrected by a small change, δA producing a difference $\frac{\delta A}{\sqrt{(A-N)^3}}$ in the numbers. But it will nearly always be found that there are some outstanding deviations which cannot be corrected for in this way. The value of B is found at once from the arithmetical progression successive numbers differing by $\frac{1}{\sqrt{B}}$. I have found this method of testing the series and calculating the constants very useful, and hope on some other occasion to return to it.

ARTHUR SCHUSTER.

UNDULATIONS IN LAKES AND INLAND SEAS DUE TO WIND AND ATMOSPHERIC PRESSURE.

IT is generally known that considerable variation takes place in the level of the surface of the water in lakes and inland seas owing to the effect of the wind in gales and during stormy weather. The minor undulations which occur at more regular intervals have not attracted the same observation, and the cause of these is still a matter of some uncertainty. In the large lakes in America, fishermen and boatmen have learnt to regard these undulations as storm warnings; and on the coasts of Europe, the rollers which break on the shore in calm weather are looked upon as indicative of a coming storm. Thus, in the Bay of Biscay frequently during the autumn and winter in calm weather a heavy sea gets up and rolls in on to the coast four-and-twenty hours before the gale which causes it arrives, and of which it is the prelude. In this case the wave action, generated on the other side of the Atlantic by the wind, travels at much greater rate than that of wind, and thus gives timely warning of the coming storm. So also on the opposite side of the Atlantic, on the coast between North Carolina and Cape Hatteras, the currents, which are there largely governed by the wind, begin to run strongly several hours in advance of the wind which causes them. In summer a change of the current from north-east to south-west is always taken as a true indication of an approaching north-east wind.

The effect of gales on tideless seas and lakes is so marked as to cause frequently considerable inconvenience and anxiety to mariners. Thus, in the Caspian Sea a gale will raise the water on one side 6 feet and depress it on the other as much, making a total difference of level of 12 feet.[1] In the Baltic easterly gales will alter the level upwards of 8 feet. In Lake Erie[1] depressions and elevations of from 2 to 4 feet are common, while occasionally heavy gales have produced a difference of level of upwards of 15 feet. Almost invariably about the time of the spring equinox strong gales occur from the east, raising the water from 4 to 6 feet at the west end of the lake, and depressing it to a similar extent at the east end, making a total difference of from 8 to 12 feet. About the time of the autumn equinox gales from the west lower the water 7 to 8 feet at the west side, and raise it 5 to 8 feet at the east end, making a difference from the normal level of from 12 to 16 feet. An illustration is given by Mr. Blunt, the engineer, who reported on the subject for the United States Commission as to the way in which the navigation of the lakes and of the rivers connected with them is affected by storms acting on the surface of the water. A steamer which had to make a trip down the river found the water at the pier from which she started, five miles from the mouth, had receded to 7½ feet below the normal level. In the river, flats were showing where a few days before they had found 8 feet of water. In the middle of the bay a large dredger was aground where there ought to have been 17 feet of water.

In addition to these larger oscillations, there are also minor undulations which occur at varying intervals, the largest period for a complete oscillation not exceeding half an hour, and the alteration in the level of the water not more than from three to four inches. The phenomena had been noted by Duillier on the Swiss Lakes in the middle of the last century, the name locally given to them being *Seiches*. In 1804 Vaucher also investigated the

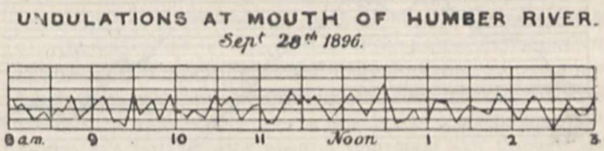


FIG. 1.

matter and published an account of his researches, his experience being that they were common to all the lakes; that they recurred at all seasons of the year, but most frequently in spring and autumn, the greatest oscillation, however, occurring in the summer; and that the intervals between the oscillations did not exceed twenty to twenty-five minutes, and more frequently less.

A few years since the writer had occasion to investigate the oscillations which took place in one of the Norfolk Broads, and which were taken as showing that the water was tidal. It was found that variations of from half an inch to two and three inches in the level of the water took place periodically, and at times when the atmosphere was calm. Observations spread over a considerable time proved that these undulations were not coincident with the rise and fall of the tides, and that they had no direct connection with the ebb and flow in the river with which this Broad was connected.

The character of the undulations on Lake Superior has been investigated by Mr. Napier Denison, and the results communicated to the Canadian Institute in February 1897, in a paper entitled "The great lakes as a sensitive barometer." For the purpose of tracing these curves Mr. Denison had two self-recording gauges constructed, one being fixed at the mouth of the river Humber, and the other at the Burlington Canal. The results of one day's reading at the mouth of the Humber are shown in Fig. 1, which is sufficient generally to illustrate the result of the readings obtained, and as showing the rapid undulations upon the lakes during light winds and fine weather preceding a severe storm. (The divisions in the above

[1] "Tidal Rivers," chap. v. (Longmans, Green, and Co.).

[1] Report of Deep Waterways Commission, U.S.A. (Washington, 1897).

diagram represent inches.) The undulations generally vary from three to four inches at intervals of from fourteen to eighteen minutes. The centre of the storm which caused these oscillations was over the State of Florida, 1300 miles distant. This storm centre travelled slowly but directly to the lake region, where it caused a severe gale. These lake undulations are found to be of a more sensitive character than the indications of approaching storms given by the barometer. Mr. Denison is of opinion that these oscillations are due to the action of atmospheric waves or billows in passing over the surface of the lakes, which tend to form minute undulations upon the surface corresponding in length to these billows, and becoming magnified when they reach narrower and shallower portions, until finally they assume the proportions recorded upon the instrument.

Attention has also recently been directed to the minor undulations which occur in tidal waters by Mr. W. Bell Dawson, the Government surveyor engaged in the tidal survey of the Gulf of St. Lawrence, in a paper presented to the Royal Society of Canada in May 1895, entitled "Notes on secondary undulations." These undulatory disturbances in the regular rise and fall of the tides in the Gulf of St. Lawrence are plainly marked on the records of the self-registering tide gauges, their magnitude being in proportion to the amplitude of the tides. Similar undulations have also been observed in the Mediterranean at Malta. The illustration (Fig. 2,

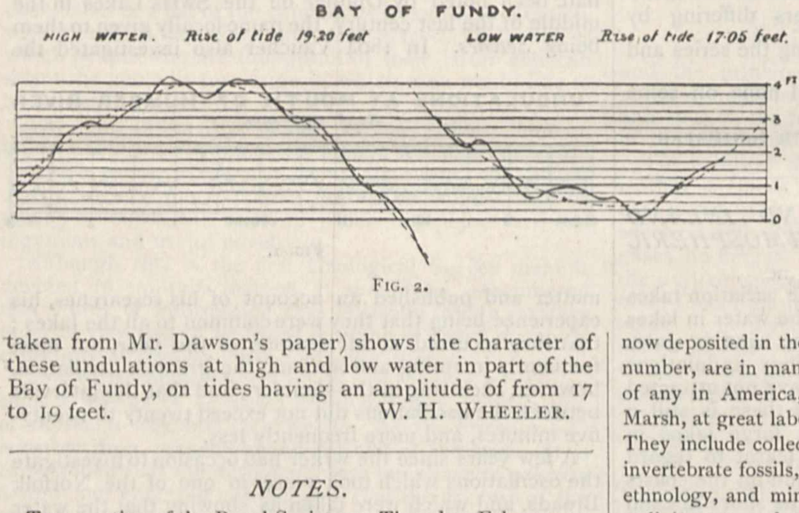


FIG. 2.

taken from Mr. Dawson's paper) shows the character of these undulations at high and low water in part of the Bay of Fundy, on tides having an amplitude of from 17 to 19 feet.

W. H. WHEELER.

NOTES.

THE meeting of the Royal Society on Thursday, February 24, will be devoted to a discussion of the "scientific advantages of an Antarctic Expedition." The debate will be opened by Dr. John Murray, F.R.S., of the *Challenger*.

PROF. L. CREMONA, professor of higher mathematics in the University of Rome, has been elected a Correspondant of the Paris Academy of Sciences, in succession to the late Prof. Sylvester.

H.R.H. THE PRINCE OF WALES has been graciously pleased to accept the post of Patron of the fourth International Congress of Zoology, to be held at Cambridge next August.

A MEETING will be held in Manchester on February 16 to take into consideration such steps as may seem desirable to assist the Executive Committee in making the Zoological Congress this year thoroughly successful. The Literary and Philosophical Society have put their rooms at the disposal of the meeting, and Mr. J. Cosmo Melvill will take the chair at 5 o'clock on that day. This appears to us to be an excellent movement, and one worthy of imitation in other large centres. Zoologists who propose to be present should communicate with Prof. Hickson, F.R.S., at the Owens College, Manchester.

MR. THOMAS H. BLAKESLEY has resigned his seat at the Council Board of the Physical Society. He is, therefore, no longer hon. secretary of that Society.

IT has been decided to publish, under the auspices of the Physical Society and the Institution of Electrical Engineers, a series of abstracts of English, American, and foreign papers on physics and electrical engineering.

THE Harvard University, Cambridge, Mass., has invited Dr. Hans Reusch, Director of the Norwegian Geological Survey, to give two series of lectures—one on "Vulcanism," the other on "the Geology of Scandinavia." Dr. Reusch will return to Christiania in June.

AT the annual meeting of the Royal Microscopical Society on Wednesday, January 19, the President, after reviewing the progress in microscopical science during the past year, gave for his address an account of the manner in which achromatic doublets and triplets were practically calculated. The President explained by drawings on the blackboard the general scope of the paper, which, owing to its mathematical treatment, could not be read verbatim.

THE death is announced of Dr. Samuel Newth, author of "A First Book of Natural Philosophy," which has had a very large sale, and "The Elements of Mathematics, including Hydrostatics." In 1855 Dr. Newth became professor of mathematics and ecclesiastical history in the New College, St. John's Wood, and succeeded Dr. Halley as principal of the College in 1872, retiring from this post in 1889.

WE learn from *Science* that, at the meeting of the Corporation of Yale University on January 13, Prof. O. C. Marsh, professor of palæontology, formally presented to the University the valuable scientific collections belonging to him, now deposited in the Peabody Museum. These collections, six in number, are in many respects the most extensive and valuable of any in America, and have been brought together by Prof. Marsh, at great labour and expense, during the last thirty years. They include collections of vertebrate fossils, fossil footprints, invertebrate fossils, recent osteology, American archæology and ethnology, and minerals. The palæontological collections are well known, and were mainly secured by Prof. Marsh during his explorations in the Rocky Mountains. They include most of the type specimens he has described in his various publications. The collection of osteology and that of American archæology are also extensive and of great interest. The present value of all these collections makes this the most important gift to natural science that Yale has yet received. The President and Fellows of Yale accepted Prof. Marsh's gift by a unanimous vote, and expressed their high appreciation of his generosity to the University.

AMONG the papers to be read at forthcoming meetings of the Society of Arts are the following:—Ordinary meetings (Wednesday evenings, at eight o'clock): February 23, children's sight, by Mr. R. Brudenell Carter; March 2, kites, their theory and practice, by Captain B. F. S. Baden-Powell; March 9, Linde's method of producing extreme cold and liquefying air, by Prof. J. A. Ewing, F.R.S.; March 16, the recent history of paper-making, by Mr. Clayton Beadle; March 23, the preparation of meat extracts, by Mr. C. R. Valentine; March 30, telegraphy across space, by Prof. Silvanus P. Thompson, F.R.S. Indian Section (Thursday afternoons, at 4.30 o'clock): February 17, the plague in Bombay, by Dr. Herbert Mills Birdwood; March 31, the earthquake in Assam, by Mr. Henry Luttman-Johnson. Foreign and Colonial Section (Tuesday afternoons at 4.30 o'clock): February 15, the goldfields of Klondike and British Columbia, by Mr. W. Hamilton Merritt. April 5, the sugar industry in the West Indies, by Mr. T. R. Tufnell. Cantor Lectures (Monday evenings, at eight o'clock): Prof. W. Noel Hartley, F.R.S., the thermo-chemistry of the Bessemer process (three lectures); Dr. D. Morris, C.M.G., india-rubber (two lectures); Prof. Carus Wilson, electric traction (four lectures).

A FEW particulars with reference to the late Dr. George Henry Horn, President of the American Entomological Society, are given in the *Entomologist's Monthly Magazine*. Dr. Horn was born April 7, 1840, in Philadelphia, and died November 24, 1897. He graduated in medicine in 1861, and from 1862 to 1866 was surgeon in the U.S. army. Subsequently he established himself as a physician in Philadelphia, and had an extensive practice. Before he graduated he published papers on recent and fossil corals, but eventually turned his attention entirely to North American *Coleoptera*, as a pupil of, and fellow-worker with, Leconte, until the death of the latter in 1883, and afterwards on his own account. It has been said that if the death of Leconte was a severe blow to North American coleopterology, that of Horn is probably greater. His first entomological paper was published in 1860, and was followed by others (jointly or separately) to the number of about 150, appearing almost entirely in America, but he worked out the *Eucnemidæ* for the "Biologia Centrali-Americana." As already announced, his collections, and a sum of money, have been left to the American Entomological Society, of which he had been long President.

PROF. DAVID P. TODD, Director of Amherst College Observatory, Amherst, Massachusetts, U.S.A., has nearly completed a bibliography of eclipse research to join on with Ranyard's classic work published many years ago in the *Memoirs* of the Royal Astronomical Society. He would be glad to receive copies of papers and titles of works and articles published since 1875.

THE Lincolnshire Science Society, the establishment of which was referred to in NATURE of December 30, 1897, should apparently have been christened the Lincoln Science Society; for a prospectus just received shows that a Lincolnshire Naturalists' Union has been in existence several years. There is hardly room for two county Societies having the same aims and objects, and the establishment of the new Society cannot but have a prejudicial effect upon the older Union, which ought to represent the combined forces of the different local societies in Lincolnshire. For the spirit of competition to enter into the matter at all is a mistake, and if the two organisations do not arrive at a concordat, the work of one will prejudice rather than assist the work of the other. It appears that the Lincolnshire Naturalists' Union initiated a scheme for the formation of a County Museum before the new Society took up the matter.

IN the last number of the U.S. *Monthly Weather Review* (October 1897), the editor draws attention to a proposal for establishing a meteorological station on Satulah Mountain, North Carolina, at an altitude of about 5000 feet. The summit of the peak is fairly level, and, with the exception of about a quarter of a mile, is accessible by vehicles. Prof. Abbe points out that a continuous record at the summit would undoubtedly contribute to the elucidation of some interesting meteorological problems, but that in view of the many unsuccessful attempts to maintain self-recording instruments in isolated places, watchful observers would be necessary. Systematic observations are being made at great elevations by means of balloons and kites, and these efforts may be usefully supplemented by renewed attention to the establishment of mountain stations.

AT the meeting of the French Meteorological Society on January 4, M. Moureaux made an important communication on the results of a mission entrusted to him by the Imperial Geographical Society of St. Petersburg with reference to the magnetic exploration of the Government of Koursk. The whole area of this province is intensely disturbed, and the differences between theory and observation are so great that it is not possible to draw isomagnetic lines. At two points situated about 450 yards apart the declinations are -11° and $+45^\circ$. In one district the declination at two stations about a mile and a quarter apart varied from -34° to $+96^\circ$. The dip ranged from 48° to 79°, and the horizontal component reached 0·59, whereas the maximum normal value of this element in the equatorial regions is below 0·40. From these observations it results that the magnetic force in that locality is as great as it would be in the immediate vicinity of the magnetic poles. So far as is known at present, there is nothing near the surface of the ground to cause these anomalies.

THE tracing of the pretty curves formed by compounding pendulum vibrations of different periods is a fascinating pastime of which we were beginning to believe the resources were pretty well exhausted. Prof. Charles Schlichter, of Winconsin, has, however, discovered "fresh woods and pastures new" by extending the method to space of three dimensions, and representing, by the aid of the stereoscope, the resultant of harmonic motions of three frequencies in three different directions mutually at right angles. To do this, Prof. Schlichter attaches a miniature electric lamp to the bob of a Blackburn pendulum vibrating in a horizontal plane, and photographs the tiny speck of light by means of a stereoscopic camera attached to a pendulum which swings in a vertical plane about a horizontal axis through the optical centres of the lenses. This last pendulum gives the third vibration-component. When the diagrams are viewed through the stereoscope, the curves spring out into relief like bent wires; their forms for many of the higher ratios, such as 5 : 6 : 9 or 5 : 8 : 9 being very striking.

EXPERIMENTS on the action of Röntgen rays on vegetable life have hitherto mostly led to negative results; but Signor G. Tolomei, writing in the *Atti dei Lincei*, is led to the conclusion that their action is identical with that of light. On exposing to the action of Röntgen rays branches of *Elodea canadensis* immersed in water charged with carbonic anhydride, evolution of bubbles took place as in the presence of sunshine or electric or magnesium light. The same similarity was observed in the effects on the lower vegetable forms, both Röntgen rays and light causing retardation in the absorption of oxygen by *Mycoderma aceti*, and in the evolution of carbonic anhydride by Saccharomyces. Again, in their action on *Bacillus anthracis* the Röntgen rays behave in the same way as sunshine, but in a minor degree; when a gelatine film was exposed for twenty-four hours to the radiations from a Crookes' tube, with the interposition of a zinc screen having an X-shaped aperture, the letter appeared transparent on an opaque background. That the action was due to destruction of the germs, and not to the generation of any toxic quality in the agar, was proved thus: when a sterilised film was partially exposed to the rays, and subsequently brought into contact with a stratum of dried spores, the spores began to germinate all over the film; but when the stratum of spores was exposed to the rays, the screen with the letter X being interposed, and the film subsequently brought into contact with them, only those spores which had been protected from the Röntgen rays developed, and the letter X was distinctly seen. Signor Tolomei attributes the previous failure to obtain such effects to the short duration of the exposures.

A LENGTHY report of the Committee, appointed by the Academy of Science and Literature at Montpellier, to inquire into the alleged vision through opaque objects, appears in *La Semaine Médicale* (January 19). The Committee prepared three letters, the contents of which could not be known to them, by writing words and numbers on sixty-four cards, placing them two and two into envelopes, and selecting three of the thirty-two envelopes haphazard; these three were carefully sealed. One envelope was sewn into the coat, another placed in the pocket of a member; the third, along with half an exposed photographic plate, was wrapped in many thicknesses of paper and placed in a box, which was also sealed. At Narbonne the box containing the envelope and plate was placed on Dr. Ferroul's table, since that was the usual position of the documents which had already been read by Mlle. X. The Committee then walked to Mlle. X.'s abode, about 300 metres from Dr. Ferroul's house. Mlle. X. did not succeed in reading the contents of the envelopes carried by the members of the Committee, and at first no success attended attempts to describe the contents of the sealed box. About an hour and a half after the commencement of the séance, during which time Mlle. X.'s sister passed to and fro, and Mlle. X. herself left the room on more than one occasion, the contents of the box were more or less correctly described. On re-examining the box the Committee came to the conclusion that it had been opened, and on developing the contained piece of photographic plate along with the other part, the former piece was fogged, although the latter developed perfectly.

The British Medical Journal of January 22 contains a reprint of the special inquiry on the relative efficiency of certain kinds of water filters which has been carried out for the *Journal*. Many of the conclusions arrived at are by no means encouraging; for example, an examination of the portable filters supplied for Army Field Service revealed the fact that not one of these afforded any protection against water-borne disease; that, on the contrary, "they would tend to increase rather than diminish the risk incurred by those making use of them, since when such filters had once been charged with contaminated water they would continue for some time afterwards to discharge the disease germs into the 'filtered' water." This is a very serious matter, and which, considering the numbers of cases of dysentery which have already occurred in the present Indian frontier war, might well demand the immediate attention of the Army Medical Department. The filter of the future remains as yet, it would seem, "a castle in the air"; where efficiency is procured, the rate of filtration is often such as to preclude it from practical use. It appears, however, likely that diatomaceous earths or natural stone will be generally preferred to denser media such as porcelain, these three being, amongst the materials at present in use for filters, the only ones which apparently supply an efficient filtering medium. The same number of the *Journal* contains a communication by E. H. Hankin on "a simple method of checking cholera in Indian villages," which consists in treating the wells in an infected district with potassium permanganate, a sufficient quantity being added in each case to give a pink colour lasting for several hours to the water. This plan appears to have produced favourable results in combating cholera outbreaks, and in some places even the natives have been induced to disinfect their wells by its means.

THE immense lava-sheets that cover an area of some two hundred thousand square miles in the Deccan of India have been looked upon as the grandest example of vulcanism in the world; but an even more extensive outpouring of similar material must formerly have been evident in the northern hemisphere, if we accept the conclusions reached by Messrs. Newton and Teall from a study of the geological collections made in Franz Josef Land by the Jackson-Harmsworth Expedition (*Quart. Journ. Geol. Soc.*, December 1897). That archipelago is formed of the fragments of an ancient basalt-plateau which must have stretched far beyond its present limits. Similar igneous rocks are found in Spitsbergen, Jan Mayen, Iceland, Greenland, the Faeroës, the Hebrides and North Ireland; and the authors are inclined to regard all these areas as the isolated fragments of a formerly continuous land-area, the greater part of which has sunk to form the northern portion of the North Atlantic Ocean. The period of this outpouring of lava was probably the end of Cretaceous and beginning of Tertiary times. This period seems to have been distinguished by similar occurrences in other parts of the world, for the great lava-flows of the Deccan and of Abyssinia are of the same age.

PROF. A. RICCÒ contributes to the latest *Bollettino* of the Italian Seismological Society an account of the Geodynamic Observatory of Catania, founded in 1891, and now one of the best equipped in Italy. It is situated beneath the astrophysical observatory, in the cellar of the former Benedictine convent. The principal instrument is one of Cancani's great seismometrographs, consisting of a pendulum 25·3 metres long and a mass of 300 kg., whose movements are magnified twelve and a half times, and recorded by two pens on a strip of paper moving at the rate of 60 cm. an hour. In addition to this valuable apparatus are two other seismometrographs (Brassart's and Cecchi's), a Guzzanti microseismoscope, one of Agamennone's photographically recording tromometers, a Cancani photochronograph, which, at the moment of a shock, photographs the face of a clock, four seismographic pendulums of different lengths and masses, ten seismoscopes of various patterns for calling attention to the occurrence of a shock, and a puteometer which records the movements of the water-surface in a well 32½ metres deep.

WE have received from the Meteorological Reporter for Western India a copy of his "Brief Sketch of the Meteorology of the Bombay Presidency for the Year 1896–97." The weather during the year presented several features of unusual character: for instance, unseasonable distribution of rainfall, for, although the annual amount was above the average in most districts, the deficiency was very great in September and October, and it was owing to this that the crops withered and caused widespread famine. Another feature was the prevalence of abnormally high temperatures; in April and October the means were respectively 6° and 7° above the average. These conditions appeared to have considerable effect upon the plague; from August to November the mortality increased with an abnormal rise of temperature, and *vice versâ*, whereas the high temperature of April appears to have had the effect of decreasing the mortality in that month. This report contains some interesting details of floods in the river Tápti since 1727; the highest flood on record—viz. 100¼ feet—occurred in July 1883, while that of July 1896—viz. 98 feet—occupies the third place on record.

THE part for January 1898 of "The Garden," edited by Mr. W. Robinson, presents a very attractive contents to the gardener and horticulturist. There are longer or shorter notes on almost every department of gardening; and no less than four coloured plates, besides numerous woodcuts, are included in the price of one shilling.

In the *Journal* of the Royal Society of Bengal for 1897 (part ii. No. 2) is a brief article by Mr. F. Finn, of the Indian Museum, on the Theory of Warning Colours and of Mimicry. It records a series of experiments on a tree-shrew, *Tupaia ferruginea*, and on a bull-frog, *Rana tigrina*, but the results do not appear to be very conclusive.

DR. L. MESHCINELLI, of Vicenza, has issued a prospectus of a proposed Iconograph of all Fossil Fungi at present known. It will be published, probably in the earlier half of the present year, in the form of a quarto volume, with an atlas of more than thirty plates. The price to subscribers will be 30 francs, delivered free.

IN a paper in *Natural Science* for August 1897, Mr. G. W. Bulman adopts very much the view of Prof. Plateau, that bees are not primarily attracted to flowers by their conspicuous colour, especially that they have no special partiality for blue. He also contests the statement that either honey-bees or wild bees are constant in their visits to the same species. Somewhat similar results appear to have been arrived at by Mr. Albert Gale from observations in Australia, of the record of which we find a commencement in the *Agricultural Gazette of New South Wales* for November 1897.

IN our recent review of the "Vita Medica" of the late Sir B. W. Richardson, the author's part in emphasising the distinction between "enteric and typhoid (*sic*) fevers" was alluded to (p. 265). Our readers perceived at once, no doubt, that the name "typhoid" had crept into the text in place of typhus.

UNDER the title of *The Home University*, the publication of a magazine and note-book for private students of various branches of knowledge has just been commenced. The idea of the editors of the new periodical is to give the home-student assistance on difficult points, and furnish him with aids to memory. "We shall assume," it is added, "that, in addition to a knowledge of their own language, our readers possess the rudiments of French, Latin, German, and Greek, and that respecting Geography, History, Poetry, and the Natural Sciences they have made some kind of a beginning." The editors purpose not so much to try to increase knowledge as to convey it, and we wish them success in their undertaking, notwithstanding the fact that science takes a minor place in the first number of their educational medium. The periodical is published by the Educational Museum, Haslemere, and by Messrs. West, Newman, and Co.

THE additions to the Zoological Society's Gardens during the past week include a Red Fox (*Canis fulvus*) from North America, presented by Mr. F. C. Ingram; four Virginian Opossums (*Didelphys virginiana*) from North America, presented by Mr. J. D. Sprunt; two Secretary Vultures (*Serpentarius reptilivorus*) from South Africa, presented by Mr. J. E. Matcham; a Laughing Kingfisher (*Dacelo gigantea*), a Lace Monitor (*Varanus varius*), a Blue-tongued Lizard (*Tiliqua scincoides*), two Stump-tailed Lizards (*Trachydosurus rugosus*) from Australia, presented by Mr. J. D. Waley; a Leopard (*Felis pardus*) from Ceylon, a Derbian Wallaby (*Macropus derbianus*) from Australia, deposited; two Uvæan Parrakeets (*Nymphicus uvæensis*) from the island of Uvea, Loyalty Group; two Black-headed Caiques (*Caica melanocephala*) from Demerara, an Ashy-black Ape (*Macacus ocreatus*) from the East Indies, three Curlews (*Numenius arquata*), three Oyster-catchers (*Hæmatopus ostralegus*) from Holland, purchased.

OUR ASTRONOMICAL COLUMN.

THE SOLAR ECLIPSE.—Mr. F. W. Dyson, the Chief Assistant at the Greenwich Observatory, has sent the following letter to the press:—"Prof. Turner telegraphs from Bombay that the observations of the solar eclipse were very successful. The photographs taken by the Astronomer Royal, Prof. Turner, Captain Hills, Mr. Newall, and Dr. Copeland, have all been developed, and the results are excellent. Captain Hills has succeeded in photographing the spectrum of the reversing layer, and Prof. Turner has obtained marked results as to the amount of polarisation of the corona."

LARGE AND SMALL PROPER MOTIONS.—In the *Astronomische Nachrichten* (No. 3466) Prof. Kapteyn announces the discovery of a star with an exceedingly large proper motion; this is the star in the Cordoba Zone Catalogue 5.243h., of about the 8th magnitude, but probably slightly variable, and having an orange-yellow colour. Its position from the "Cape" observations of 1897·8 for epoch 1875 is α = 5h. 6m. 56·0s., and $\delta = -44°$ 60′·530, which position is in the constellation of Pictor. The result of the investigations of Mr. Innes, of the Cape Observatory, and Prof. Kapteyn, gives the proper motion in a great circle as 8″·7, or in R.A., + 0·621s., and Decl. − 5″·70, which will be seen is even greater than that of the "runaway" star 1830 Groombridge, the proper motion of which, it will be remembered, is 7″·05 in a great circle, or in R.A. + 0·346s., and Decl. − 5″·78. We shall await with interest the determination of the parallax of this remarkable star, in order to discriminate whether its large proper motion is real or chiefly due to its close proximity to our system.

In contrast with the above, Mr. J. G. Porter has re-computed the proper motion of the star Bradley 2444^a = 3250, availing himself of a much longer series of observations than those from which Dr. Auwers deduced the values +0·0040s. and +0″·128; and while Mr. Porter's result of + 0·0024s. and − 0″·030 (as given in the *Astronomical Journal*, No. 422) confirms the small motion in right ascension, it negatives entirely the motion in declination; he therefore suggests that Dr. Auwers' result seems to have been due to a wrong reduction of the declinations of D'Agelet and Lalande.

THE COMET OF 1892 II.—It is not often that an opportunity occurs of basing the determination of a comet orbit on observations extending over so long a period as that available in the present instance. The series commenced in 1892, March 19, and ended 1893, January 12, during which period the comet passed over about 107° of true anomaly. The definitive orbit in this case proves to be hyperbolic, and the final result is entitled to considerable weight. The only unsatisfactory feature about it is the amount of the residuals in some of the normal places. Dr. L. Steiner, of O'Gyalla, who has made the calculations, bases them on Dr. Schorr's elements, from which he derives by comparison with his computed ephemeris, twelve normal places, necessarily varying considerably in point of accuracy. The solution of the equations of condition founded on these normal places gives for the excentricity the value 1·004404. The residuals to which we have referred as not being quite satisfactory do not occur at the end of the series, when the comet would necessarily be faintest and the observations scarcest, but in the middle of the series, practically from June to October. This is to some extent perhaps to be explained by the fact, that the comet was about that time very faint in telescopes of moderate size, and these observations, made with difficulty, may have had an injurious effect on those derived from the use of larger instruments. This explanation is not entirely satisfactory, for in one instance the normal place rests entirely on the measures made at one Observatory, that of Bordeaux. Dr. Steiner tries by alterations of the assigned "weights" to reduce these residuals, but the result is not quite satisfactory. Under the best circumstances, and when the excentricity is brought down to 1·000345, the sum of the squares of the residuals in the hyperbola is 103″·2, while on the assumption of parabolic motion the same sum is 279″·5. The orbit is almost perpendicular to the plane of the ecliptic.

WINNECKE'S COMET = *a* 1898.—From further observations made by Prof. Perrine at the Lick Observatory a new ephemeris of this comet has been determined; this, together with the elements, are given in the *Astronomical Journal* (No. 424) as follows:—

Elements.

T = 1898 March 20·392 G.M.T.

$$\left.\begin{aligned}\omega &= 173°\ 21'\ 16''\!\cdot\!0\\ \Omega &= 100\ \ 51\ \ 45\cdot5\\ i &= 16\ \ 59\ \ 34\cdot0\end{aligned}\right\}1898\cdot0$$

$\log e = 9\cdot854161$

$\log a = 0\cdot510521$

Ephemeris for Greenwich Midnight.

1898.	App. α (h. m s.)	App. δ (° ′ ″)	log Δ
Feb. 1·5	17 25 1·63	−10 53 56·4	
3·5	34 33·95	11 17 21·0	0·1527
5·5	44 14·66	11 39 50·2	
7·5	17 54 3·34	−12 1 18·5	0·1457

The nearest bright star to the comet during this period is *o* Serpentis, which rises about four hours in advance of the sun.

ROWLAND'S TABLES.—In the December number of the *Astrophysical Journal*, tables of *corrections* and *additions* to Prof. H. A. Rowland's table of solar spectrum wave-lengths are given. The errors in wave-length have been carefully determined for the whole table, but the identification of solar lines with the lines of the elements in the spectrum of the electric arc has been revised only from wave-length 3722 to 4175. Therefore the corrections and additions to the identifications have been given only for the most important lines between these limits. A few small solar lines have been added to the table.

The changes in wave-length are few, most of them being additions to the identifications.

NEBULÆ NEAR CASTOR.—Prof. Barnard records in the *Astronomical Journal* (No. 422) a list of new nebulæ which he found with the 12-inch equatorial when he first went to Mount Hamilton, and which have remained unpublished until now. There are five within less than a degree of Castor, whose positions here given are reduced to 1860·0—the epoch of Dreyer's New General Catalogue.

No.	α (h. m. s.)	δ (° ′)	Description.
1	7 24 23	+31 44·4	Close p. 10 mag. star.
2	7 24 43	+31 35·5	Small, faint.
3	7 25 12	+31 40·5	Small, 3 S ∗s in curve 2′ p. ±
4	7 25 27	+31 40·5	Very, very faint.
5	7 25 59	+31 31·0	Small, faint.

Prof. Barnard remarks that he has discovered several nests of these nebulæ, but in most other cases the individual nebulæ are very much smaller.

DR. KARL NECKER.—The name of yet another astronomer has to be added to the death roll of last year. Dr. Karl Necker, who occupied the position of assistant in various observatories, was unfortunately killed in a railway accident at Cairo, to which town he had removed for the benefit of his health. Born in 1867, and with his University career only completed in 1893, he entered first the Strassburg Observatory as a temporary assistant, but after a few months removed to Vienna, and in the Küffner Observatory devoted himself to making a series of observations on the prime vertical. When Dr. Halm left Strassburg to occupy his present position at Edinburgh, Dr. Necker returned to fill the vacancy thus created, and was engaged in the fundamental meridian work. But his health compelled him to take long rests, and finally he was recommended to reside in Cairo, where he hoped to secure a position in the Khedival Observatory. This hope was defeated by his tragic death, while making a short excursion to the Sinai Peninsula.

INSTINCT AND INTELLIGENCE IN ANIMALS.[1]

BIOLOGY is a science not only of the dead but of the living The behaviour of animals, not less than their form and structure, demands our careful study. Both are dependent on that heredity which is a distinguishing characteristic of the organic world. And in each case heredity has a double part to play. It provides much that is relatively fixed and stereotyped; but it provides also a certain amount of plasticity or ability to conform to the modifying conditions of the environment. Instinctive behaviour belongs to the former category; intelligent behaviour to the latter. When a caterpillar spins its silken cocoon, unaided, untaught, and without the guidance of previous experience; or when a newly-mated bird builds her nest and undertakes the patient labours of incubation before experience can have begotten anticipations of the coming brood; we say that the behaviour is instinctive. But when an animal learns the lessons of life, and modifies its procedure in accordance with the results of its individual experience, we no longer use the term instinctive, but intelligent. Instinct, therefore, comprises those phases of active life which exhibit such hereditary definiteness as fits the several members of a species to meet certain oft-recurring or vitally-important needs. To intelligence belong those more varied modes of procedure which an animal adopts in adaptation to the peculiar circumstances of its individual existence. Instinctive acts take their place in the class of what are now generally known as congenital characters; intelligent acts in the class of acquired characters.

But the study of instinct and intelligence in animals opens up problems in a different field of scientific investigation. They fall within the sphere not only of biological but also of psychological inquiry. And in any adequate treatment of their nature and origin we must endeavour to combine the results reached by different methods of research in one harmonious doctrine. This involves difficulties both practical and theoretical. For those invertebrates, such as the insects, which to the naturalist present such admirable examples of instinctive behaviour, are animals concerning whose mental processes the cautious psychologist is least disposed to express a definite opinion. While the higher mammalia, with whose psychology we can deal with greater confidence, exhibit less typical instincts, are more subject to the disturbing influence of imitation, and, from the greater complexity of their behaviour, present increased difficulties to the investigator who desires carefully to distinguish what is congenital from what is acquired.

Nor do the difficulties end here. For the term "instinct" is commonly, and not without reason, employed by psychologists with a somewhat different significance, and in a wider sense than is necessary or even desirable in biology. The naturalist is concerned only with those types of behaviour which lie open to his study by the methods of direct observation. He distinguishes the racial adaptation which is due to congenital definiteness, from that individual accommodation to circumstances, which is an acquired character. But for the psychologist instinct and intelligence comprise also the antecedent conditions in and through which these two types of animal activity arise. The one type includes the conscious impulse which in part determines an instinctive response; the other includes the choice and control which characterise an intelligent act. When a spider spins its silken web, or a stickleback builds the nest in which his mate may lay her eggs, the naturalist describes the process and seeks its origin in the history of the race; but the psychologist inquires also by what impulse the individual is prompted to the performance. And when racial and instinctive behaviour is modified in accordance with the demands of special circumstances, the naturalist observes the change and discusses whether such modifications are hereditary; but the psychologist inquires also the conditions under which experience guides the modification along specially adaptive lines. Each has his part to play in the complete interpretation of the facts. And each should consent to such definitions as may lead to an interpretation which is harmonious in its results.

In view, therefore, of the special difficulties attendant on a combined biological and psychological treatment of the problems of animal behaviour, I have devoted my attention especially to some members of the group of birds in the early days of their life. And I shall therefore draw my examples of instinct and intelligence almost entirely from this class of animals. The organisation and the sensory endowments of birds are not so divergent from those of man, with whose psychology alone we are adequately conversant, as to render cautious conclusions as to their mental states altogether untrustworthy; when hatched in an incubator they are removed from that parental influence which makes the study of the behaviour of mammals more difficult; while the highly developed condition in which many of them first see the light of day affords opportunity for observing congenital modes of procedure under more favourable circumstances than are presented by any other vertebrate animals. Even with these specially selected subjects for investigation, however, it is only by a sympathetic study and a careful analysis of their behaviour that what is congenital can be distinguished from what is acquired. For from the early hours of their free and active life, the influence of the lessons taught by experience makes itself felt. Their actions are the joint product of instinct and intelligence, the congenital modes of behaviour being liable to continual modification in adaptation to special circumstances.

[1] A Friday evening discourse delivered at the Royal Institution, on January 28, by Prof. C. Lloyd Morgan.

Instinct appears to furnish a ground-plan of procedure which is shaped by intelligence to the needs of individual life. And it is often hard to distinguish the original instinctive plan from the subsequent intelligent modification.

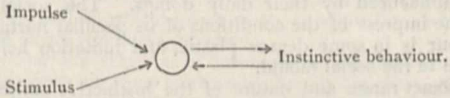
It is not my purpose to describe here in detail, as I have done elsewhere, the results of these observations. It will suffice to indicate some of the more salient facts. In the matter of feeding, the callow young of such birds as the jackdaw, jay, or thrush, instinctively open wide their beaks for the food to be thrust into their mouths. Before the eyes have opened the external stimulus to the act of gaping would seem to be either a sound or the shaking of the nest when the parent bird perches upon it. Under experimental conditions, in the absence of parents, almost any sound, such as a low whistle, lip-sound, or click of the tongue, will set the hungry nestlings agape, as will also any shaking or tapping of the box which forms their artificial nest. And no matter what is placed in the mouth the reflex acts of swallowing are initiated. But even in these remarkably organic responses the influence of experience soon makes itself felt. For if the material given is wrong in kind or distasteful, the effect is that the bird ceases to gape as before to the stimulus. Nor does it continue to open the beak when appropriate food has been given to the point of satisfaction. These facts show that the instinctive act is prompted by an impulse of internal origin, hunger, supplemented by a stimulus of external origin, at first auditory but later on, when the eyes are opened, visual. They show also that when the internal promptings of hunger cease, owing to satisfaction, the sensory stimulus by itself is no longer operative. And they show, too, that the diverse acts of gaping and swallowing become so far connected, that the experience of distasteful morsels tends, for a while at least, to prevent further gaping to the usual stimulus.

With those birds which are active and alert soon after hatching, the instinctive acts concerned in feeding are of a different character. At first, indeed, the chick does not peck at grains which are placed before it; and this is probably due to the fact that the promptings of hunger do not yet make themselves felt, there being still a considerable supply of unabsorbed yolk. Soon, however, the little bird pecks with much, but not quite perfect, accuracy at small near objects. But here again experience rapidly plays its part. For if distasteful objects, such as bits of orange-peel, are the first materials given, pecking at them soon ceases; and if this be repeated, the little bird cannot again be induced to peck, and may even die of starvation. This makes it very difficult to rear by hand some birds, such as plovers, whose natural food, in due variety, is not readily obtainable. It must be remembered, too, that under natural conditions the parent bird calls the young and indicates with her beak the appropriate food; and this appears to afford an additional stimulus to the act of pecking. Pheasants and partridges seem to be more dependent on this parental guidance than domestic chicks, and they are more easily reared when they have somewhat older birds as models whose pecking they may imitate. Passing allusion may here be made to a type of instinctive response in some respects intermediate between the upward gaping of the jay and the downward pecking of the chick. It is seen in the young moorhen, which pecks upwards at food held above it and cannot at first be induced to take any notice of food on the ground. Under natural conditions it is fed by the parent, which holds the food above the little bird as it floats on the water.

We have then, in these simple instinctive acts, examples of behaviour which is congenitally definite in type for each particular species; of actions which are the joint product of an internal factor, hunger, and an external factor, sensory impressions; of complex modes of procedure which subserve certain vital needs of the organism. It should be mentioned, however, that the relative definiteness of instinctive responses has been subjected to criticism from a psychological source. It has been urged that the nutritive instincts, the play instincts, the parental instincts, those of self-preservation and those concerned in reproduction, are so varied and multifarious, that definiteness is the last thing that can be predicated of them. Varied and multifarious they are indeed; and each of the groups above mentioned contains many differing examples. But that is because we are dealing with comprehensive classes of instinctive behaviour. The fact that the group of fishes includes organisms of such wide structural diversity, as the salmon, the globe-fish, the eel, and the sole, does not affect the fact that these species have a relatively definite structure each after his kind. It is only when we treat a group of fishes as if it were an individual fish that we are troubled by indefiniteness of structure. And it is only when we deal with a group of instincts, comprised under a class-name, as if it were a particular instinctive act, that we fail to find that definiteness which, to the naturalist, is so remarkable.

From the physiological point of view, instinctive procedure would seem to have its origin in an orderly group of outgoing neural discharges from the central office of the nervous system giving rise to a definite set of muscular contractions. And this appears to have an organic basis in a congenital preformation in the nervous centres, the activity of which is called into play by incoming messages, both from internal organs in a state of physiological need, and from the external world through the organs of special sense. The naturalist fixes his attention chiefly on the visible behaviour which is for him the essential feature of the instinctive act. But in view of the requirements of psychological interpretation it is advisable to comprise under the term instinct, in any particular manifestation of its existence, the net result of four things: first, internal messages giving rise to the impulse; secondly, the external stimuli which co-operate with the impulse to affect the nervous centres; thirdly, the active response due to the coordinated outgoing discharges; and fourthly, the message from the organs concerned in the behaviour by which the central nervous system is further affected. Now I shall here assume, without pausing to adduce the arguments in favour of this view, that consciousness is stirred in the brain, only by incoming messages. If this be so, the outgoing discharges which produce the behaviour are themselves unconscious. Their function is to call forth adaptive movements; and these movements give rise to messages which, so to speak, afford to consciousness information that the instinctive act is in progress. Hence I have urged that the instinctive *performance* is an organic and unconscious matter of the purely physiological order, though its effects are quickly communicated to consciousness in the form of definite messages from the motor organs. I have not denied that the stimuli of sight, touch, hearing and so forth, also have conscious effects; I do not deny (though here I may have spoken too guardedly) that the initiating impulse of internal origin, is conscious. In both these cases we have messages transmitted to the central office of the brain. What I have ventured to urge is that the consciousness of instinctive behaviour, *in its completed form*, does not arise until further messages come in from the motor organs implicated in the performance of the act, lodging information at the central office concerning the nature of the movements.

A diagram will perhaps serve to make this conception clearer.



The circle represents the brain, in some part of which consciousness arises through the effects of incoming nerve-currents. Under the influence of the two primary groups of messages, due to impulse and to sensory stimulus, consciousness is evoked, and the brain is thrown into a state of neural strain, which is relieved by the outgoing discharge to the organs concerned in the instinctive behaviour. It is this outgoing discharge which I regard as unconscious. But the actions which are thus produced give rise to a secondary group of incoming messages from the moving limbs. This it is which gives origin to the consciousness of instinctive behaviour as such. And I regard it as psychologically important that these incoming messages are already grouped, so as to afford to consciousness information, rather of the net results of movement than of their subsidiary details.

So much for our general scheme. If now we turn to the instinctive behaviour concerned in locomotion, we find a congenital basis upon which the perfected activities are founded. There is no elaborate process of learning to walk on the part of the chick; ducklings and moorhens a few hours old swim with perfect ease when they are placed in water; these birds also dive without previous practice or preliminary abortive attempts; while young swallows, if their wings are sufficiently large and strong, are capable of short and guided flights the first time they are committed to the air. In these cases neither the internal impulse, nor the sensory stimuli, are so well defined as in the case of the nutritive activities. The impulse probably takes the form of an uneasy tendency to be up and doing, perhaps due to ill-defined nervous thrills from the organs of locomotion which are in need of exercise. The sensory stimuli are presumably afforded by the contact of the feet with the ground, or with the water, and by the pressure of the air on the wing-surfaces. It is a curious fact that, if young ducklings be placed on a cold and slippery surface, such as that of a japanned tea-tray, they execute rapid scrambling movements, suggestive of attempts to swim, which I have never seen in chicks, pheasants, or other land-birds.

It will not be supposed that I claim for perfected locomotion, so admirably exemplified in the graceful and powerful flight of birds, an origin that is wholly instinctive and unmodified by the teachings of experience. Here as elsewhere instinct seems to form the ground-plan of activities which intelligence moulds to finer and more delicate issues. This is the congenital basis on which is built the perfected superstructure. And if our opportunities for observation, and our methods of analysis, were equal to the task, we should be able to distinguish, in the development of behaviour, the congenital outline from the shading and detail which are gradually filled in by the pencil of experience.

The difficulties which render this analysis at the best imperfect are, therefore, twofold. In the first place, intelligence begins almost at once to exercise its modifying influence; and in the second place, many instinctive traits do not appear until long after intelligence has begun its work. Much of the intelligent detail of the living picture is filled in before the instinctive outlines are complete. The term "deferred instincts" has been applied to those congenital modes of procedure which are relatively late in development. The chick does not begin to scratch the ground, in the manner characteristic of rasorial birds, till it is four or five days old; nor does it perform the operation of sand-washing till some days later; the moorhen does not begin to flick its tail till it is about four weeks old; the jay does not perform the complex evolutions of the bath till it has left the nest and felt its legs, when the stimulus of water to the feet, and then the breast, seems to start a train of acts which, taken as a whole, are of a remarkably definite type. The development of the reproductive organs brings with it, apart from the act of pairing, a number of associated modes of behaviour—nest-building, incubation, song, dance, display, and strange aerial evolutions—which are presumably in large degree instinctive, though of this we need more definite evidence. For it is difficult to estimate with any approach to accuracy the influence of imitation. There seems to be no reason for doubting that, when an animal grows up in the society of its kind, it is affected by what we may term the traditions of its species, and falls into the ways of its fellows, its imitative tendency being subtly influenced by their daily doings. The social animal bears the impress of the conditions of its peculiar nurture. Its behaviour is in some degree plastic, and imitation helps it to conform to the social mould.

The exact range and nature of the instinctive outline, independently of those modifications of plan which are due to the inherent plasticity of the organism, are, therefore, hard to determine. And if, as we have good grounds for believing, the growth of intelligent plasticity, in any given race, is associated with a disintegration of the instinctive plan, congenital adaptation being superseded by an accommodation of a more individualistic type, to meet the needs of a more varied and complex environment, the problems with which we have to deal assume an intricacy which at present defies our most subtle analysis.

We must now turn to the consideration of the manner in which individual accommodation through the exercise of intelligence under the teachings of experience, is brought about. And it will be well to pave the way by adducing certain facts of observation.

Although the pecking of a young chick under the joint influence of hunger and the sight of a small near object, would seem to belong to the instinctive type, the selection of appropriate food, apart from the natural guidance of the hen, seems to be mainly determined by individual experience. There is no evidence that the little bird comes into the world with anything like hereditary knowledge of good and evil in things eatable. Distasteful objects are seized with not less readiness than natural food such as grain, seeds, and grubs. The conspicuous colours of certain nasty caterpillars do not appeal to any inherited power of immediate discrimination so as to save the bird from bitter experience. They seem rather to serve the purpose of rendering future avoidance, in the light of this bitter experience, more ready, rapid, and certain. Bees and wasps are seized with neither more nor less signs of fear than large flies or palatable insects. Nor does there seem to be any evidence of the hereditary recognition of natural enemies as objects of dread. Pheasants and partridges showed no sign of alarm when my dog quietly entered the room in which they were kept. When allowed to come to closer quarters, they impudently pecked at his claws. A two days chick tried to nestle down under him. Other chicks took no notice of a cat, exhibiting a complete indifference which was not reciprocated. A moorhen several weeks old would not suffer my fox-terrier to come near his own breakfast of sopped biscuit, but drove him away with angry pecks until the higher powers supervened.

It is not, of course, to be inferred from these observations that such an emotion as fear has no place in the hereditary scheme, or that the associated acts of hiding, crouching, or efforts to escape do not belong to the instinctive type. I have seen little pheasants struck motionless, plovers crouch, and moorhens scatter at the sound of a loud chord on the violin, or of a shrill whistle. A white stoneware jug, placed in their run, caused hours of uneasiness to a group of birds, including several species. But there is no evidence that, in such cases, anything like hereditary experience defines those objects which shall excite the emotion. It is the unusual and unfamiliar object, especially after some days of active life amid surroundings to which they have grown accustomed; it is the sudden sound, such as a sneeze, or rapid movement, as when a ball of paper is rolled towards them, that evokes the emotion. Hence, if the parent birds are absent, the stealthy approach of a cat causes no terror in the breasts of inexperienced fledglings. But when she leaps, and perhaps seizes one for her prey, the rest scatter in alarm, and for them the sight of a cat has in the future a new meaning.

The elementary emotions of fear, anger, and so forth, stand in a peculiar and special relationship to instinct. At first sight they seem to take rank with the internal impulses which are the part-determinants of instinctive behaviour. The crouching of a frightened plover or landrail, the dive of a scared moorhen, result partly from the external stimulus afforded by the terrifying object, partly from the emotional state which that object calls forth. But in their primary genesis I am disposed—here following to some length the lead of Prof. Wm. James—to assign to such emotions an origin similar to that of the consciousness which follows on the execution of the instinctive act. Assuming, as before, that consciousness owes its genesis to messages which reach the sensorium through incoming nerve-channels, the sensory stimuli, afforded, let us say, by the sight of a terrifying object, do not seem, in the absence of inherited experience, capable of supplying messages which in themselves are sufficient to generate the emotion of fear. Now, the well-known accompaniments of such an emotional state are disturbances of the heart-beat, the respiratory rhythm, the digestive processes, the action of the glands, and the tone of the minute blood-vessels throughout the body. And all these effects are unquestionably *produced* by outgoing discharges from the central nervous system. But they are *felt* as the result of incoming messages, like vague and disquieting rumours, transmitted to the central office from the fluttering heart, the irregular breathing, the sinking stomach, and the disturbed circulation. Is it not therefore reasonable to suppose that the emotion, in its primary genesis, is due to the effect on the sensorium of these disquieting messages? If this be admitted as a working hypothesis—and it cannot at present claim to be more than this—we reach, at any rate, a consistent scheme. As primary messages to the central office of consciousness we have, on the one hand, those due to stimuli of the special senses, and, on the other hand, those resulting from the conditions of the bodily organs, taking the form of a felt craving for their appropriate exercise. These cooperate to throw the brain into a state of unstable equilibrium or neural strain, which is relieved by outgoing streams of nervous energy. And these in turn fall into two groups; first, an orderly set of discharges to the voluntary muscles concerned in behaviour, and secondly, a more diffuse group of discharges to the heart, respiratory apparatus, digestive organs, glands, and vascular network. In so far as these are outgoing discharges, they do not directly affect consciousness. But there quickly returns upon the sensorium an orderly group of incoming messages from the motor apparatus concerned in instinctive behaviour, and a more indefinite group from the heart and other visceral organs. The former gives the well-defined consciousness of activity; the latter the relatively ill defined feelings which are classed as emotional. But so swift is the backstroke from the body to the brain that, ere the instinctive behaviour is complete, messages from the limbs—and, under the appropriate circumstances, from the heart—that is to say, of both instinctive and emotional origin—begin to be operative in consciousness, and the final stages of a given performance may be guided in the light of the experience gained during its earlier stages.

The exact manner in which consciousness exercises its guiding influence, is a matter of speculation. Perhaps the most probable hypothesis is that the cerebral hemispheres are an adjunct to the rest of the central nervous system, and exercise thereon by some such mechanism as the pyramidal tract in the human subject, a controlling influence. Given an hereditary ground-plan of automatic and instinctive responses the cerebral hemispheres may, by checking here and enforcing there, limit or extend the behaviour in definite ways. In any case, from the psychological point of view, their action is dependent on three fundamental properties: first, the retention of modifications of their structure; secondly, differential results according as these modifications have pleasurable or painful accompaniments in consciousness; and thirdly, the building of the conscious data, through association, into a system of experience. The controlling influence of this experience is the essential feature of active intelligence. Or, expressed in the almost obsolete terminology of the older psychology, intelligence is the faculty through which past experience is brought to bear on present behaviour.

Prof. Stout, whose careful work in analytical psychology is well known, has done me the service of criticising, in a private communication, my use of the phrase "past experience," urging that present experience is not less important in determining behaviour than that which is past and which can only be operative through its revival in memory. The criticism is valid in so far as it shows that I have not been sufficiently careful to define what I mean by past experience. But I certainly had in mind, though I did not clearly indicate, the inclusion of what Mr. Stout regards as present experience. My conception of "present," as I have elsewhere described it, is that short but appreciable period of time, occupying only some small fraction of a second, which is comprised in the fleeting moment of consciousness. All anterior to this, if it were but a second ago, I regard as past—past, that is to say, in origin, though still operative in the limited field of the present moment. When we are reading a paragraph and near its close, the net result of all that we have read in the earlier sentences, is present to influence the course of our thought. But the very words—"all that we *have* read"—by which we describe this familiar fact, imply that the guiding experience originated in a manner which demands the use of the past tense. Still I am none the less grateful to Mr. Stout for indicating what to many may have seemed a serious omission in my interpretation. Suffice it to say that if we include under the phrase "present experience" the occurrences of five minutes, or even of five seconds ago (all of which I regard as past), I most fully agree that present experience (in this sense) exercises a most important guiding influence.

We have distinguished four classes of messages affecting consciousness in the central office of the sensorium: first, stimuli of the special senses; secondly, internal cravings; thirdly, motor sensations due to bodily activity; and fourthly, emotional states. These are combined in subtle synthesis during the growth of experience, and are associated together in varied ways. Into the manner in which experience grows we cannot enter here. It will be sufficient to indicate very briefly the effects of this growth on the behaviour of animals in the earlier stages of their life. This may be considered from a narrower or from a broader standpoint. In the narrower view we watch how, within the field of a widening synthesis, the particular associations are formed. We see how, within experience, the taste and appearance of certain caterpillars or grubs become so associated that for the future the larva is left untouched. Or we see how the terrible pounce of the cat has become so associated with her appearance as thenceforth to render her an object of fear to enlightened sparrows. But of the physiological mechanism of association we know little.

There is a familiar game in which a marble is rolled down an inclined board at the bottom of which are numbered compartments. The lower part of the board is beset with a series of vertical pins so arranged that the marble rebounding from one to another pursues a devious course before it reaches its destination. But if we tie threads from pin to pin we may thus direct the course of the marble along definite lines. Now the brain may be roughly likened to a set of such pins, and the marble to an incoming nerve current. The congenital structure is such that a number of hereditary threads connect the pins in definite ways, and direct the discharge into appropriate channels. But a vast number of other threads are acquired in the course of individual experience. These are the links of association which direct the marble in new ways. Observation of behaviour can only give us information that new directing threads have been introduced. The psychology of association can only indicate which pins have been connected by linking threads. Even such researches as those of Flechsig can at present do no more than supplement the psychological conclusion by general anatomical evidence. Of the details of brain modification by the formation of association fibres we are still profoundly ignorant.

Nor when we turn from the narrower to the wider point of view are we in better case. We are forced to content ourselves with those generalities which are the makeshift of imperfect knowledge. Still, even such generalities are of use in showing the direction in which more exact information is to be sought. And we can, perhaps, best express the net result of acquired modification of brain-structure by saying that every item of experience makes the animal a new being with new reactive tendencies. The sparrows, which yesterday were unaffected by the stealthy approach of the cat, garrulously scatter to-day because they are not the same simple-minded sparrows that they were. The chick comes into the world possessed of certain instinctive tendencies—with certain hereditary directing threads. But at the touch of experience its needs are modified or further defined. New connecting threads are woven in the brain. On the congenital basis has been built an acquired disposition. The chick is other than it was, and reacts to old stimuli with new modes of behaviour.

In its early days the developing animal is reading the paragraph of life. Every sentence mastered is built into the tissue of experience, and leaves its impress on the plastic, yet retentive brain. By dint of repetition, the results of acquisition become more and more firmly ingrained. Habits are generated; and habit becomes second nature. The organism which to begin with was a creature of congenital impulse and reaction becomes more and more a creature of acquired habits. It is a new being, but one with needs not less imperious than those with which it was congenitally endowed.

All of this is trite and familiar enough. But it will serve its purpose if it help us to realise how large a share acquired characters take in the development of behaviour in the higher animals, and how fundamentally important is the plasticity of brain-tissue, and its retentiveness of the modifications which are impressed on its yielding substance.

Such being the relations of intelligence and instinct in the individual, what are their relations in the evolution of the race? Granting that instinctive responses are definite through heredity, how has this definiteness been brought about? Has it been through natural selection? Or are the acquired modifications of one generation transmitted through heredity to the next? Is instinct inherited habit? Darwin, who wrote before the transmission of acquired characters was seriously questioned, admitted both. And Romanes, to whose ever-kindly sympathy I am deeply indebted, still adhered to this view in spite of modern criticism. There is not much in my own observational work which has any decisive bearing on the question. But there are one or two points which are perhaps worthy of consideration. The part played by acquisition in the field of behaviour is the establishment of definite relations between particular groups of stimuli and adaptive responses. If this be so, and if acquired modifications of brain-structure be transmitted, we might reasonably expect that the sight of a dog would have a similar effect on young pheasants to that which it has on their parents. But this does not appear to be the case. Again, one might reasonably expect that the sight of water would evoke a drinking response in recently hatched birds, just as the sight or scent of a Yucca flower excites a definite response in the Yucca moth. But here, too, this is not so. Thirsty chicks and ducklings seem to be uninfluenced by the sight of water in a shallow tin. They may even run through the liquid and remain unaffected by its presence. But if they chance to peck at a grain at the bottom of the tin, or a bubble on the water, as soon as the beak touches the liquid, *this* stimulus at once evokes a drinking response again and again repeated. Why does the touch of water in the beak excite a congenital response, while the sight of water fails to do so? I believe it is because under natural conditions the chicks peck at the water in imitation of the mother, who thus shields them from the incidence of natural selection. Under these circumstances there is no opportunity for the elimination of those who fail to respond at the mere sight of water, and consequently no selective survival of those who do thus respond. But though the hen can lead her young to peck at the water, she cannot teach them the essential movements of beak, mouth, and gullet, which are necessary for the complex act of drinking. In this matter she cannot shield them from the incidence of natural selection. Those which, on pecking the water, failed to respond to the stimulus by drinking, would assuredly die of thirst and be eliminated. The rest would survive and transmit the congenital instinctive tendency. Thus it would seem that when natural selection is excluded a special mode of behaviour has not become congenitally linked with a visual stimulus; but, when natural selection is in operation, this behaviour has become so linked with a touch or taste stimulus in the beak. Similarly in the case of the pheasants and the dog. The parent birds warn the young of his approach, and thus prevent the incidence of natural selection. Hence there is no instinctive response to the sight of a terrier.

No doubt there are many cases of complex behaviour, seemingly instructive, which are difficult to explain by natural selection alone, and which have the appearance of being due to the inheritance of acquired habits. I have, however, elsewhere suggested that acquired modifications may, under the conditions of natural selection, foster the development of "coincident" variations of like nature and direction, but having their origin in the germinal substance. But into a consideration of this hypothesis I cannot here enter. Without assuming a dogmatic attitude, I am now disposed to regard the direct transmission of acquired modes of behaviour as not proven.

Thus we come back to the position, assumed at the outset, that heredity plays a double part It provides, through natural selection or otherwise, an outline sketch of relatively definite behaviour, racial in value; it provides also that necessarily-indefinite plasticity which enables an animal to acquire and to utilise experience, and thus to reach adaptation to the circumstances of its individual life. It becomes, therefore, a matter of practical inquiry to determine the proportion which the one kind of hereditary legacy bears to the other. Observation seems to show that those organisms in which the environing conditions bear the most uniform relations to a mode of life that is relatively constant, are the ones in which instinct preponderates over intelligent accommodation; while those in which we see the most varied interaction with complex circumstances, show more adaptation of the intelligent type. And the growth of individual plasticity of behaviour, in race-development, would seem to be accompanied by a disintegration of the definiteness of instinctive response, natural selection favouring rather the plastic animal capable of indefinitely varied accommodation than the more rigid type whose adaptations are congenitally defined.

I have dealt, it will be observed, only with the lower phases and earlier manifestations of intelligence. Its higher development, and the points in which it differs from the more complex modes of human procedure, offer a wide and difficult field for careful observation and cautious interpretation. I have recently attempted further investigations in this field; but they concern rather the relation of intelligence to logical thought than that of instinct to intelligence, which forms the subject of this discourse.

THE DUKE OF DEVONSHIRE ON TECHNICAL EDUCATION.

AT Eastbourne on Saturday last the Duke of Devonshire addressed the students of the art and technical classes, and in the course of his remarks he referred to educational questions of more than local interest. His remarks upon proprietary and private schools call attention to what is probably the weakest link in our educational system. In order to qualify for an assistant mastership in an elementary school, it is necessary for a teacher to serve a term of years, during which period his knowledge of the theory and practice of teaching is periodically tested; but in our private and proprietary schools any one can be a teacher, whether he possesses qualifications or not. In other words, the elementary school teacher must prove his efficiency, while the teacher in the middle-class schools—the respectable proprietary establishments—may or may not be competent to impart instruction. The result is that some of our higher-grade primary schools are the best organised and equipped institutions for teaching elementary science in the country, while the science which figures in the prospectuses of many private schools is entirely unworthy of the name. Unfortunately, the sons of artisans and shopkeepers are compelled to leave school at an early age, and so cannot take full advantage of the facilities provided by the higher-grade schools. On the other hand we have the private schools where the age of leaving is later, but there the facilities for scientific instruction are inadequate. The general result is that only a small proportion, either of the artisan class or of the sons of commercial men, receive technical instruction. It is, of course, not suggested that all private schools are inefficient, but a large proportion of them are, when considered as schools in which science is taught; and the Duke of Devonshire has done a public service in pointing out the need of subjecting them to some system of supervision.

The following is abridged from the *Times* report of the Duke of Devonshire's address:—

PROPRIETARY AND PRIVATE SCHOOLS.

I suppose that there are in Eastbourne a larger number of proprietary and private schools than in almost any other town of the same size in the country. It would be extremely interesting to have full information as to what these schools are doing and the nature of the instruction which they provide. I doubt very much whether there is any one here, or whether there is anybody anywhere, who has the means of forming or giving a complete account of what the proprietary and private schools of any particular district in the country are doing, or what is the nature of the instruction which they are providing. That appears to me to point to the need for some better organisation of education than we at present possess. Of the students who are receiving their education in the numerous proprietary schools here and in other similar schools in the country there are many, no doubt, whose future would not be dependent upon their own exertions, and who are only educating themselves, or being educated by their parents, to make them good citizens and cultivated people; but there must be a very large number in addition who are looking forward to entering into some profession or another, or into some branch of industry or of commerce. And to the parents of such students it would be of immense value and importance to have full knowledge and full information upon the character of the education which is being given at these proprietary and private schools. Some of them, no doubt, are more efficient; some are less efficient than others; but, even amongst those which are the most efficient, there must be some which are capable of giving a more valuable hint and direction of instruction to those who are going to enter upon industrial and commercial pursuits than those which may be in other directions equally efficiently organised; and it would be of the very greatest importance, in my opinion, to the schools themselves, to the parents, and to the community at large if means were at our disposal to know more of the manner in which these schools are organised and of the work which they are doing.

TECHNICAL EDUCATION ABROAD.

Foreign nations have anticipated us to a very great extent in realising the close connection which exists between education and industrial and commercial success. That is a fact which is being brought home to us almost daily in various directions of the increasing competition to which we find ourselves in every quarter exposed. It is a subject which, as your chairman has reminded you, I have frequently discussed on previous occasions, and I am not going to enter into it at any length again to-night. I will only say that the urgency of this question is now recognised by those who are educational experts or educational enthusiasts. The urgency of the question is coming to be recognised by practical men of business. Only the other day the education authority of Manchester sent out a deputation of its members to ascertain what provision was being made in Germany and Switzerland for the industrial and commercial education of the people. They published a most valuable report, in which they spoke almost with dismay of the completeness with which the education of those who were leading and directing the manufacturing and commercial enterprise of those countries was being organised; and they urged upon their fellow-citizens, in the very strongest terms, that they should not allow themselves to be left behind in the race, but that they should make an effort for the organisation of the education of their own people to bring that education up to something like the level which has been attained in those countries. And the Associated Chambers of Commerce the other day presented a memorial, a most important memorial, to the Government urging upon them that greater attention should be paid by the educational departments of the State, not to art and scientific instruction only, but to the study of foreign languages and other subjects indispensable to the successful prosecution of a commercial career. And therefore I say it is not educational enthusiasts only, but it is practical and far-headed men of business who are beginning to realise the absolute necessity of bringing up our education somewhere near, at all events, to the levels which have been attained in other countries.

ORGANISATION OF SECONDARY EDUCATION.

I have not the smallest desire to see our secondary education modelled upon one uniform pattern. I believe that we require great variety and great freedom, but I do think that it would be of advantage if both central and local organisations existed with which these private institutions might place themselves in voluntary, but, at the same time, in close connection—organisations which, by means, perhaps, of inspection, by their guidance, and by their counsel—might enable them so to organise themselves, so to co-relate themselves, as to render the instruction which they may give more valuable to the public. These are, of course, observations of a very general character, which, if they have any substance, apply equally to schools in every part of the country. Speaking of this particular district—of your own schools—I cannot help thinking that it might be of great advantage, both to them and to the community of Eastbourne, if, under the county educational authority or under your borough educational authority—there ought not to be any jealousy between different bodies of that kind—there could be established in this town of Eastbourne a scientific and technical institute, which might be of great value to the inhabitants of Eastbourne itself and also of great assistance to those educational establishments which are so numerous amongst you, and which might make use of such establishments as part of their educational course.

PRIZE SUBJECTS OF THE PARIS ACADEMY OF SCIENCES.

THE *Comptes rendus* of the Paris Academy of Sciences, for January 10, contains the list of subjects proposed for the various prizes offered by the Academy for 1898 and three succeeding years.

For the year 1898, the subject for the Grand Prize of the Mathematical Sciences is to examine and extend the part played by divergent series in analysis; for the Bordin Prize (3000 fr.), to study the questions relating to the determination, properties, and applications of systems of orthogonal curvilinear coordinates of *n* variables, indicating especially the degree of generality of these systems; the Francœur Prize (1000 fr.) and Poncelet Prize (2000 fr.), for the most useful work in the field of pure or applied mathematics. In Mechanics, the Extraordinary Prize of 6000 fr., for progress in any direction calculated to increase the efficiency of the French naval forces; the Montyon Prize (700 fr.), for inventing or improving instruments useful to the progress of agriculture, the mechanical arts or sciences; the Plumey Prize (2500 fr.), for improvements in steam engines, or any other invention contributing to the progress of steam navigation; the Fourneyron Prize (500 fr.), for the theory of the motion of bicycles, discussing more especially the conditions of stability of both rectilinear and curved motion on a horizontal or inclined plane.

In Astronomy, the Lalande Prize (540 fr.), for the most interesting observation, or the work or memoir most useful to the progress of astronomy; the Damoiseau Prize (1500 fr.), for an exposition of the theory of the perturbations of Hyperion, the satellite of Saturn, taking account principally of the action of Titan, comparing the observations with the theory, and hence deducing the mass of Titan; the Valz Prize (460 fr.), for the most interesting astronomical observation made during the current year; the Janssen Prize (a gold medal), for discoveries in physical astronomy.

In Statistics, the Montyon Prize (500 fr.), for questions relating to French statistics; and in Chemistry, the Jecker Prize (10,000 fr.), for work in organic chemistry.

In Mineralogy and Geology, the Vaillant Prize (4000 fr.), for a work discussing and making known the indications furnished by the microscopical study of sedimentary rocks (particularly secondary and tertiary) from the point of view of their genesis and of the modifications which they have undergone since their deposit in structure and composition, organised bodies being included.

In Botany, the Barbier Prize (2000 fr.), for discoveries bearing upon the art of healing; the Desmazières Prize (1600 fr.), for the best study of Cryptogams; the Montagne Prizes (1000 fr. and 500 fr.), for memoirs bearing on the anatomy, physiology, and development of the lower Cryptogams; the De la Fons-Melicocq (900 fr.), for botanical work on the North of France; and the Thore Prize (200 fr.) to the author of the best work on the cellular Cryptogams of Europe.

In Anatomy and Zoology, the Savigny Prize (975 fr.), for the assistance of young travelling zoologists, not receiving Governmental support, who have specially occupied themselves with the invertebrate fauna of Egypt and Syria.

In Medicine and Surgery, a Montyon Prize for discoveries or inventions bearing on medicine or surgery; the Barbier Prize (2000 fr.), for the most valuable discovery in relation to the art of healing (surgery, medicine, pharmacy or botany); the Bréant Prize (100,000 fr.), for a discovery leading to the complete suppression of Asiatic cholera; the Godard Prize (1000 fr.), for the best memoir on the anatomy, physiology, and pathology of the genito-urinary organs; also the Bellion (1400 fr.); Mège Lallemand (1800 fr.), and Baron Larrey Prizes.

In Physiology, a Montyon Prize (750 fr.); the Pourat Prize (1400 fr.), for a memoir on the motor nerves of the stomach, and the Philipeaux Prize (890 fr.).

In Physical Geography, the Gay Prize (2500 fr.), for a comparison between the marine flora of the Bay of Biscay with that of neighbouring regions and of the Mediterranean; also to see if the fauna and flora lead to similar conclusions. Other general prizes offered are the Arago Medal, the Montyon Prize (unhealthy trades), the Trémont Prize (1100 fr.), the Gegner Prize (4000 fr.), the Delalande-Guérineau Prize (1000 fr.), the Jérome Ponti Prize (3500 fr.), the Leconte Prize (50,000 fr.), for a new and important discovery in mathematics, physics, chemistry, natural history, or medical science; the Tchiatcheff Prize (3000 fr.), for exploration of the lesser-known portions of Asia; the Houllevigue Prize, the Cahours Prize (3000 fr.), for the assistance of young chemists of promise; the Saintour Prize (3000 fr.), the Kastner-Boursault Prize (2000 fr.), for the best work on the applications of electricity in the arts, industry, and commerce; and the Estrade-Delcros Prize (8000 fr.).

Of these prizes, those of Montagne and Delalande-Guèrineau are expressly restricted to Frenchmen, whilst the Lalande, La Caze, Delesse, Desmazières, Tchiatcheff, and Leconte Prizes are awarded without distinction of nationality.

MR. CAVENDISH ON HIS JOURNEY TO LAKE RUDOLF.

ON Monday last, Mr. H. S. H. Cavendish described his recent journey in East Africa before the Royal Geographical Society. Accompanied by Lieut. H. Andrew, Mr. Cavendish left Berbera on September 5, 1896, and proceeded in a southerly direction to Lugh, on the Juba River, afterwards striking westwards up the Dau. Here it proved very difficult to get into communication with the natives, as the caravan was at first taken for an Abyssinian force. The country of the Boran Gallas, with whom Dr. Donaldson Smith had so much trouble, was, however, soon reached. Mr. Cavendish gave some interesting details respecting this tribe, which he found most friendly, and anxious to be placed under British protection. Whilst in the Boran country the travellers were able to wander about at will without escort. At Egder, in about lat. 4° N., long. 39° E., Dr. Donaldson Smith's route was left, and the caravan made direct for Lake Stefanie, passing a remarkable crater with a lake at the bottom, from which salt is obtained. At the south end of Lake Stefanie a large outcrop of coal was discovered, which had evidently been laid bare by the action of the water. It was in this neighbourhood that Mr. Cavendish had an adventure with an elephant which well-nigh proved fatal. Some valuable information was collected with regard to the tribes on the western side of the lake, the principal of which are the Wanderobo (allied to the Borans), the Harbora, Hamerkoke (nomads), and Galubba. Striking across to the north end of Lake Rudolf, the travellers reached the country of the Reshiat or Darsonich, a race of traders, but, like other tribes of the country, almost entirely unclothed. A remarkable weapon in use among them is a kind of knife-bracelet, which is covered with a sheath, except during a fight.

The two Europeans now separated, Mr. Cavendish proceeding northwards to explore the river flowing into the north end of Lake Rudolf, whilst Lieut. Andrew marched down the east side of the lake. Like Captain Bòttego, Mr. Cavendish is confident that the river, which he followed up for some distance, is identical with the Omo of travellers in the south of Abyssinia. The Legumi and Murle, who dwell on its banks, wear caps of human hair, into which ostrich feathers are stuck to denote the number of men killed by the wearer. The Murle also use the wrist-knife above described, as well as a kind of battle-axe with a wooden blade, covered with a tightly-stretched skin. Crossing the Omo, Mr. Cavendish proceeded southwards to the country of the Turkana on the west of Lake Rudolf, which had previously been entered by no travellers except the members of Bòttego's expedition. Mount Lubur, an extinct volcano, was here ascended. The crossing of a sort of neutral zone at the border of the Turkana country is taken as a declaration of war, and the caravan was in consequence continually harassed by attacks from this warlike people. They are in the habit of making night attacks, and it was only by camping each night on spits of sand running out into the lake that these were successfully resisted. Finally friendly relations were established, and the Turkana guided the party through the difficult mountainous country towards the south. At the south end of Lake Rudolf Mr. Cavendish found that the Teleki volcano had entirely disappeared, the Ligob who dwelt in its neighbourhood telling him that, six months before, the lake had overflowed, and as the waters rushed towards the mountain there was a great explosion, since which a lava-plain has taken the place of the volcano, while a new crater has opened about three miles further south. The whole country seems to show signs of recent volcanic activity, for on the further march to the south, the caravan being once more united, a new lake was discovered containing a smouldering volcano, near which the water was quite hot to the touch. Where the water had dried up, the lake-bed was of black mud, hard on the surface, but hot and liquid below. Beyond this the country was exceedingly difficult, and water was scarce; but the caravan finally reached Lake Baringo, and thence made its way through known country to the east coast.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Dr. E. W. Hobson, F.R.S., has been appointed a Governor of Derby School.

The original researches of Mr. J. A. McClelland, advanced student of Trinity College, have been approved by the Special Board for Physics and Chemistry as a qualification for the B.A. degree. Mr. McClelland's papers refer to work on the kathode, Lenard, and Röntgen rays.

Eighteen additional freshmen, including one advanced student, were matriculated on January 28.

MR. W. R. LANG has been appointed lecturer on organic chemistry at Glasgow University.

MR. PERCY A. HILLHOUSE has been appointed professor of naval architecture in the Imperial University, Tokio.

THE Cameron Prize of the University of Edinburgh, open each year to any one who in the preceding five years has made any "highly important and valuable additions to practical therapeutics," has (says the *British Medical Journal*) been awarded to Prof. T. R. Fraser, F.R.S., in recognition of his researches and practical therapeutic observations in connection with strophanthus.

THE fifth annual meeting of the Association of Technical Institutions was held on Friday last. Sir Bernhard Samuelson, Bart., who was elected president of the Association for the year 1898, delivered an address on the need of organised technical instruction. Resolutions were passed in favour of a system of examination and diplomas suitable more especially for day students who aspire to take leading positions in the various technical industries; and urging upon the Department of Science and Art the necessity of modifying the recent circular respecting the proportion of students who continue their studies in Schools of Science.

THE report of the Board of Agriculture on the distribution of the Parliamentary grant in aid of agricultural education in Great Britain during the year 1896–7 shows that sums amounting to a total of 6950*l.* were distributed in specific grants to fourteen institutions as follows:—Durham College of Science, Newcastle-on-Tyne, 1000*l.*; University College of North Wales, Bangor, 800*l.*; Yorkshire College, Leeds, 800*l.*; University College of Wales, Aberystwyth, 800*l.*; Reading University Extension College, 800*l.*; Nottingham University College, 600*l.*; Cambridge and Counties Agricultural Education Committee, 500*l.*; South-Eastern Agricultural College, Wye, 400*l.*; Eastern Counties Dairy Institute, Ipswich, 300*l.*; British Dairy Institute, Reading, 300*l.*; Bath and West and Southern Counties Society, 300*l.*; Royal Botanic Garden, Edinburgh, 150*l.*; Highland and Agricultural Society, 100*l.*; Agricultural Research Association, Aberdeen, 100*l.* The *Record of Technical and Secondary Education* states that in addition to the distribution of these sums, the Board have also undertaken the inspection of the agricultural work of the institutions and bodies assisted, as well as that of seven County Councils. A valuable feature of the report is the detailed information given regarding the agricultural instruction provided by the English and Welsh County Councils. From statistics compiled from this Return, it appears that a total sum of over 80,000*l.* (including a proportion of capital expenditure) was devoted during 1896–7 to agricultural instruction by sixty English and Welsh County Councils. Dairy instruction was taught in all but eight English and Welsh counties, and the manual processes of agriculture in about one-half the English counties.

AT the meeting of the London County Council on Tuesday, the Technical Education Board submitted an estimate of the amount that should be appropriated for technical education during the year 1898–99. The sum of 150,000*l.* was granted for the year 1896–97, and of this a balance of 13,384*l.* was unexpended. For the year ending March 31, 1899, it is estimated that 170,000*l.* will be required, in addition to this balance. The amount of the estimated expenditure is arrived at as follows:—For technical departments of polytechnics, 35,900*l.*; for various technical institutes, 36,000*l.*; for technical departments of public secondary day schools and allowance for fees, books, &c., of the Board's county scholars, 28,500*l.*; for higher education, 5500*l.*; for county scholarships, 31,025*l.*; for teaching in art, science, and technology and manual instruction, 27,800*l.*; for domestic economy, 7350*l.*; for commercial subjects, 3300*l.*; for museums (chiefly art examples), 1500*l.*; and for expenses of administration, 7300*l.* In a tabular statement the Board gives since the year 1890 the amount of the Exchequer contribution from beer and spirit duties, out of which the grant for technical education is made. From this it appears that the amount now asked for technical education, 170,000*l.*, will absorb almost the whole of the amount which the Council will receive from the beer and spirit duties, which is estimated for the ensuing year at 177,000*l.* The Council's grants towards technical education in London have gradually increased from the year 1892–93, when the grant was only 29,000*l.*, up to the present year, when the grant was 150,000*l.* For the ensuing year an additional 20,000*l.* is asked for.

ON Thursday last, at Grocers' Hall, the Speaker distributed the awards gained by students attending the technical colleges and schools which have been established by the City and Guilds of London Institute, under the direct management of its executive committee and maintained out of the funds of the institute contributed by the Corporation and Livery companies of the City of London. In the course of an address to the company, the speaker expressed surprise that more Englishmen did not come forward to fill in their own country posts in which a knowledge of chemistry was required. He confessed that, speaking as an outsider, he did not understand why it was that Germany was not only able to manufacture all the chemists she needed herself, but also to export to different parts of the world fifty chemists for every one who was exported by this country. He ventured to suggest, speaking in all humility, that there was a large field in this direction for the youth of England, if scientifically inclined. He thought it probable that most of those present who were practically acquainted with technical education would agree with him that they had not done nearly as much in this matter—and chemistry was an example of it—as they ought to do and would have to do. A great deal had been done in the past ten or twenty years; but they began late, and they had not yet caught up some other nations, and much had still to be done in this country in order to provide the facilities that were needed to furnish their sons with the knowledge that was necessary to enable them to carry on the commercial business of the country. The City and Guilds Institute had in the most munificent manner spent on its technical colleges in the course of the past eighteen years about half a million out of the funds over which it had control; but could they go on relying upon private munificence so much as they had done for the purposes of technical education? He ventured to think that the time had come when there should be some system supported by funds, if necessary, of some public nature by which colleges should be founded in the great centres where they were needed, and branch colleges of a similar description in smaller places where they were wanted. The whole scheme of technical education seemed to him to have come to the point at which it required some further consideration. In connection with this subject one had often to speak of Germany and Switzerland, but he was quite sure that they did not speak of them in any spirit of jealousy, but, on the contrary, in a spirit of admiring emulation of their work. They must take what they could that was best from those countries and adopt it, and leave the latter to act in a similar manner towards this country.

SCIENTIFIC SERIALS.

American Journal of Science, January.—A new harmonic analyser, by A. A. Michelson and S. W. Stroud. This is an instrument designed to sum up as many as eighty terms of a Fourier series, or to analyse a given curve into its original series. The pen which traces the curve is worked up and down by a lever controlled by a spring. This spring is stretched by an excentric, which imparts a "simple harmonic" variation to the force. The stretching is resisted by another spring. Eighty such elements are connected together, with one resisting spring to counterbalance the sum of the elementary springs. The pen therefore moves in accordance with the sum of the elementary periodic motions. The authors obtain by this machine the mathematical series representing the profile of a human face.—A new form of physical pendulum, by J. S. Stevens. The error introduced into the ordinary physical pendulum by the fact that the knife-edges and clamp affect the moment of inertia may be eliminated by boring a hole into the rod and screwing the knife edges a little way in, so that they offset the mass of brass bored out.—The Protostegan plastron, by G. R. Wieland. This is a restoration of the plastron of two specimens of the turtle described before as *Archelon ischyros*.—Phosphorescence produced by electrification, by J. Trowbridge and J. E. Burbank. When a piece of fluorspar is first exposed to the action of X-rays, and subsequently heated, it shows a bright phosphorescence. The same phenomenon may be produced by exposing the mineral to an electric brush discharge, and subsequently heating it. It is probable, therefore, that the X-rays produce an electrification of the fluorspar.—On iron meteorites, as nodular structures in stony meteorites, by H. L. Preston. It is an important fact that of over 100 falls and finds of siderites or iron meteorites but nine have been seen to fall, while of the aerolites or stony meteorites of over 400 falls and finds, more than one-half have been seen to fall. The author gives several reasons in support of the view that the siderites are merely the crystallised metallic nodules contained in the larger and more conspicuous stony meteorites.

SOCIETIES AND ACADEMIES.

LONDON.

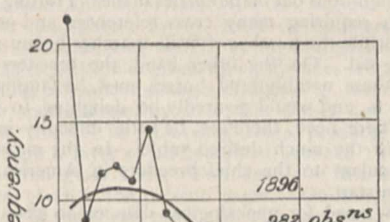
Royal Society, December 13, 1897.—"An Examination into the Registered Speeds of American Trotting Horses, with Remarks on their Value as Hereditary Data." By Francis Galton, D.C.L., F.R.S.

It is strange that the huge sums spent on the breeding of pedigree stock, whether of horses, cattle, or other animals, should not give rise to systematic publications of authentic records in a form suitable for scientific inquiry into the laws of heredity. An almost solitary exception to the disregard shown by breeders and owners, of exact measurements for publication in stud books, exists in the United States with respect to the measured speed of "trotters" and "pacers" under defined conditions. The performance of one mile by a trotter, harnessed to a two-wheeled vehicle, carrying a weight of not less than 150 lbs. inclusive of the driver, in 2 minutes 30 seconds qualifies him for entry in the "Trotting Register," giving him, as it were, a pass-degree into a class of horses whose several utmost speeds or "records" are there published.

The system of timing was first put into practice more than fifty years ago, and has since been developed and improved. In 1892 a considerable change was made in the conditions by the introduction of bicycle wheels with pneumatic tyres, which produced a gain of speed, the amount of which is much discussed, but which a prevalent opinion rates at 5 seconds in the mile. Thenceforward the records are comparable on nearly equal terms. All trotting performances up to the 2′ 30″ standard are registered in the large and closely printed volumes of "Wallace's Year Book," published under the authority of the American Trotting Association. Vols. viii.–xii. refer to the years 1892–6, and it is from the entries in these that the following remarks are based.

The object of my inquiry was to test the suitability of these trotting (and pacing) records for investigations into the laws of heredity. I had to determine whether the observations fell into a tolerably smooth curve; and, if so, whether that curve was a tolerable approach to the normal curve of frequency. In the latter event the observations would fall into line with numerous anthropometric and other measures which have been often discussed, and which, when treated by methods in which the arithmetic mean is employed, yield results that accord with observed facts.

I had 5705 extracts made from the entries published in the Year Books for the five years 1892–6. It was tedious work, and I thought it unnecessary to repeat it to check the results, being satisfied after some examination that they were quite accurate enough for general conclusions. They were arranged in columns; the first to the left contained entries of all observations recorded as 2′ 29·0″, 29¼″, 29½″, or 29¾″; that is of all under 2′ 30″ down to 2′ 29″ inclusive. The second column referred to 2′ 28″ 0, 28″¼, 28″½, and 28″¾, and so on with the rest. These were then reduced to percentages and diagrams were drawn from them, of which the following, for the year 1896, is one; it will serve as a fair sample of the other four.



If divided by the eye into imaginary columns corresponding to those in the tables, the point representing the sum of the observations of 2′ 29″·0′, 29″¼, 29″½ and 29″¾ will be found in the middle of the first imaginary column, that is to say it stands vertically above the point that lies half way between 29 and 30 on the scale along the base. The dots are connected by thin lines to show the trace or curve of the observations. The smooth curves are those of normal frequency, calculated from the values of the mean (M) and of the probable error (P.E.), which are given in the diagrams.

Leaving aside for the moment the strange pinnacle that rises on the extreme left of every diagram, we see that the traces of the rest of the observations run very roughly, but not intolerably so. In each diagram they seem to be disposed about a fundamentally smooth curve. Considering the smallness of the interval, namely, only one second, that separates the observations assigned to each pair of successive columns, together with the experience derived from other kinds of statistical curves, it seems to me that the run of the observations is good enough to certify their general trustworthiness. As regards the pinnacle it is different matter, and is one which when beginning work, was did, on the 1892 entries only, was very perplexing. However, by persevering with the other years, it became increasingly plain that the pinnacle was a false maximum; in 1896 it was certain that the true maximum lay well within the portion of the curve included in the diagram. The explanation of the pinnacle then became obvious[1]; it was that the tolerance granted to those horses who failed by only a little to qualify themselves, was extended considerably beyond the quarter second for which I was prepared. The cases of 2′ 30·0″ were few; they do not appear in the diagram, but their addition would be quite insufficient to remove the difficulty, If the pinnacle were distributed among *two* adjacent columns outside and to the left of the diagram it would smooth away the incongruity, so I suspect that cases of "under 2′ 32″ and down to 2′ 30″" are habitually rated at a trifle less than 2′ 30″. Consequently I had no hesitation in wholly disregarding the entries that helped to make the pinnacle, namely, the whole of those contained in the first column to the left in every one of the diagrams. The course thereupon became clear and straightforward. I estimated the position of the mean value for each year, from inspection of the curve of that year, allowing myself to be somewhat biassed in estimating its point of culmination by the curves of the adjacent years; similarly as to the probable error. Now that the curves are drawn, I see that somewhat better fits might have been made, but they are close enough to show the existence of a fair amount of correspondence between the observed values and those calculated according to the law of normal frequency. It is near enough to remove hesitation in working with the arithmetic mean.

I now come to the fundamental purpose of this memoir, which is to point out the existence in the registers of the American Trotting Association, of a store of material most valuable to inquirers into the laws of heredity, which accumulates and increases in value year by year. But it seems to me hardly worth while to discuss hereditary influence on speed in horses, unless the records of at least their sires and of their dams, and those of each of their four grandparents, as well as their own record, are all known. Even in this case (according, at least, to my own theory) one quarter of the hereditary influences are unknown and have to be inferred. It is practically impossible to make an adequate collection of the names of horses who fulfil the above conditions out of the entries in the "Trotting Register," each search requiring many cross references and occupying a long time, while the number of futile searches before attaining a success is great. On the other hand, the breeders and possessors of these notably bred horses must be familiar with the required facts, and would assuredly be delighted to have them known. There need, therefore, be little difficulty in obtaining materials for the much desired table. In the meantime I am sending circulars to the chief breeders in America, in hopes of making a start.

The great need for genealogical data of an exact numerical kind, by those who prosecute inquiries into the laws of heredity, is the justification that I offer for submitting these remarks to the Royal Society.

Physical Society, January 21.—Mr. Shelford Bidwell, President, in the chair.—Prof. Fitzgerald exhibited some photographs by Mr. Preston in illustration of the Zeeman effect, for various cases, including those of iron, cadmium, zinc, and sodium. These photographs and the method of obtaining them have already been described. The cause of doubling is now attributed by Prof. Fitzgerald to absorption by the surrounding vapour. In a particular case he examined a double line that exists in one of the photographs. Under the polariser the two lines are at first distinctly seen; but when the polariser is turned, a thin line appears in the middle, and this central line is, therefore, circularly polarised in a direction opposite to that of the outer pair of lines. The reason for the appearance of doubling in the first position of the polariser is that the central line is there completely absorbed out by the surrounding vapour.—Prof. Oliver Lodge then gave a communication concerning his work on "Electric Signalling without Connecting-wires." From the nature of the oscillatory disturbances emanating from any of the customary forms of Hertz vibrator, syntony has hitherto been only very partially available as a means for discriminating between receivers. There is in fact so rapid a decrease in the amplitude of the vibrations that almost any receiver can respond to some extent. Discrimination by syntony is possible with magnetic systems of space telegraphy where the magnetic energy much exceeds the electric, *i.e.* as between two separated inductive coils; and by the use of such coils, appropriately applied, the author has been able to attain fair syntony even with true Hertz waves, *i.e.* he has constructed spark-gap oscillators, with sufficient persistence of vibration, and syntonised resonators. The "coherer" principle can be applied to either a purely magnetic or to the Hertzian system. It was first used by Prof. Lodge in devising lightning-guards, and afterwards in his magnetic system of telegraphy by inductive circuits, each in series with a Leyden-jar; a pair of knobs in near contact, or other over-flow gap, being provided in the receiving apparatus. This was the first meaning of a "coherer" in the electrical sense as used by Prof. Lodge. It referred to a *single* contact between two metal knobs. The term has since been extended by others to the filings-tube of M. Branly, and some confusion has arisen, for M. Branly does not consider that simple coherence and break explains fully the behaviour of his instrument. Prof. Lodge is disposed to agree, for he finds that the resistance of almost any form of coherer varies in rough proportion to the received impulses, and that there are other peculiarities (to be mentioned later). He is, therefore, inclined to think that the action cannot after all be entirely explained as due to mere "welding," but that there is something more to be learnt about it. The sensitiveness of a coherer depends upon the number of loose contacts; it is a maximum for a single contact, *i.e.* for a needle-point lightly touching a steel spring. With this sensitive coherer, hardly any "tapping-back" is required for decoherence, but it wants delicate treatment when properly adjusted, and the greatest current through it should not approach a milliampere. On the other hand, a Branly tube rather improves under rough treatment; in such a tube the author prefers to use iron filings in the best possible vacuum; brass, too, is very good, but rather less easy to manage. Aluminium is thoroughly bad, and gold, for an opposite reason, will not work—its surface is too clean. Points, or small surfaces for making contact with the filings, are better than large surfaces. The usual method of connecting the coherer across the gap of an ordinary Hertz receiver, in parallel with the telegraph instrument and battery, has the unavoidable objection that they shunt away part of the received oscillations. With the syntonic receiver of Prof. Lodge, which contains no gap, but a closed wire coil instead, this difficulty no longer exists; for the coherer can now be in series with the detecting instrument, and in so far as these obstruct the oscillations they may be shunted out in various ways, as the author describes. The main feature of his new syntonised vibrators is this self-inductance coil, whose function it is to prolong the duration of the oscillations, and thereby to render syntony possible. Although such a coil acts disadvantageously in so far as it possesses resistance, the resistance does not increase so fast as the self-induction. The coil should consist of thick copper of highest conductivity, and it should have maximum inductance for given resistance. For similar reasons, the capacity-areas should also be of highest conductivity, their dimensions should increase outwards from the spark-gap, as triangles. The receiver must have no gap, it should be accurately bridged over when a transmitter is used as receiver. The limit of speed of response depends upon the telegraphic instrument. Dr. Muirhead adapted a siphon-recorder to the purpose, because it is one of the quickest responders; he arranged it so that it could be used with intermittent currents direct. Under these intermittent impulses the siphon trembles; and instead of the ordinary siphon signals, the slip is marked with dots and dashes. Constant mechanical tremor is usually employed for decoherence, but the author finds that decoherence can be brought about by electrical means, without any mechanical tremor, by connecting the coherer momentarily to a circuit less effective as a collector than that of the proper capacity-areas of the syntonised receiver. The battery and galvanometer detector-circuit may be used for this purpose, the coherer being momentarily connected to it, and while so connected letting it experience an impulse from a distance. Prof. Lodge has designed a revolving commutator by means of which the coherer can be rapidly changed over from the resonating circuit to the instru-

[1] I should like to take the opportunity afforded by the appearance of an abstract of my memoir in NATURE to correct a questionable suspicion, namely, that the pinnacles in the diagrams are due to tolerance shown towards horses who failed by a very little to qualify for the much-coveted rank of standard trotters. I am assured on excellent authority that the strict conditions of timing make this impossible (among other reasons there are three timers). On the other hand, there is a vast competition *just* to pass the 2′ 30″ limit; and when a horse has done so, his owner often does not care to train him for racing but rather to utilise him at once for breeding or other purposes. The question is too complicated to discuss here at length. Suffice it that the 2′ 29″ to 2′ 30″ records are not homogeneous with the rest, and should be discarded as I proposed.—F. G.

ment-circuit, and finally to the "tapping-back" apparatus. A coherer is more sensitive when thus isolated and exposed to the full influence of the received oscillations; the subsequent detection of the effect by altered connections is very convenient for laboratory measurements. A diagram of a series of plotted measurements showed that the resistance of an undisturbed filings-tube is approximately a direct function of the intensity of the received stimulus, whether successive stimuli increased or decreased in strength. This electrical process of "tapping-back" is to be depended upon, but the process long continued fatigues the tube until a mechanical shake is employed to restore it. Large size apparatus made by Dr. Muirhead for actual distant syntonic work was exhibited, and means were shown for protecting and isolating the coherer when its receiving areas were being used as emitters; also a switch used for changing at one moment all the connections from "sending" to "receiving." Prof. Threlfall said he had come to the same conclusion as Prof. Lodge as to the advisability of diminishing the number of contact-points in the coherer. He had endeavoured to produce longer and more persistent waves, and thus to set afield greater effective energy. It was desirable to keep the waves as parallel as possible. He thought there was some probability that the wave-fronts could be altered and rendered more conformable by a process of diffraction. Mr. Rutherford also had found it best to work with long waves. He fully appreciated the advantage of increasing the capacity of the oscillator by extending the surface of the metallic plates. Mr. Campbell-Swinton asked whether experiments had been made to verify Hertz results as to the influence of reflectors behind oscillators and receivers. He had found them disadvantageous. A single wire behind either apparatus seemed partially to annul the effect. He also asked whether Prof. Lodge had observed the extraordinary sensitiveness of coherers to small changes of current in neighbouring circuits. Prof. Lodge, in reply, said he had observed the sensitiveness to slight sudden variations of current referred to by Mr. Campbell Swinton; for instance, when electric lamps were switched on or off. The effect of mirrors had been studied by Prof. Fitzgerald. They required to be of large dimensions as compared to the oscillator and receiver, otherwise the true reflections were not obtained. Dr. Silvanus Thompson afterwards exhibited a Tesla oscillator. This apparatus is intended to replace the two induction coils and spark-gap arrangements used by Mr. Tesla for high frequency experiments. It consists of an induction coil with a separate self-inductance coil in the primary circuit. This self-inductance coil is also used as an electromagnet for the separate interrupter of the primary circuit. A condenser is connected between one end of the primary coil and one terminal of the interrupter, so as to include both of them between its terminals. The primary is a single turn of copper strip, six inches wide. The secondary is one layer of thick wire; each turn separated from the next by an air space. The supply current, about half an ampere, may be taken from the electric-light mains at almost any voltage from 50 to 200, direct or alternating. Prof. Lodge said it would work quite well at 10 volts. He pointed out also that if the straight discharge-rods at the spark-gap were free to slide, the discharge drove them back into their sockets. Prof. Fitzgerald said it was stated at Toronto that the spark was broken at the interrupter when the condenser was charged, and that by the time the condenser was ready to discharge, the contact at the interrupter had been made again. It seemed to him that the condenser discharges and surgings must take place at a rate far higher than the period of the mechanical movement of the interrupter. The condenser charges and discharges were very rapid. It was not what is ordinarily called the "time constant" that was involved, for that only referred to constant voltage. Here the voltage was changing very rapidly indeed. Prof. Herschel asked if such an apparatus was suitable for work with Röntgen rays. Dr. Thompson, in reply, congratulated Mr. Tesla upon the perfect working and compactness of his invention. The present form was not suited for Röntgen ray experiments, but Mr. Tesla had designed a special coil that was excellent for that purpose. —The President proposed votes of thanks, and the meeting was adjourned until February 11.

PARIS.

Academy of Sciences, January 24.—M. Wolf in the chair. —On the reduction of some double integrals, and on a new invariant in the theory of algebraic surfaces, by M. Émile Picard.—Addition to a preceding note on the Zeeman effect, by M. A Cornu. Some results of measurements showing that the magnitude of the separation produced increases with the refrangibility of the ray.—On the conditions of formation of alkaline carbides, and the carbides of magnesium and of the alkaline earths, by M. Henri Moissan. Metallic potassium, if left for a long time in acetylene, slowly but completely decomposes the gas giving hydrogen and C_2HK. Sodium gives a similar compound when sealed up with liquid acetylene, and this C_2HNa, heated in a vacuum, gives up pure acetylene, leaving sodium carbide C_2Na_2 behind; at a red heat this is decomposed into carbon and sodium. The potassium compound behaves similarly, neither sodium, potassium, nor magnesium carbides being able to exist at the temperature of the electric furnace.—Histological mechanism of cicatrisation; on true immediate reunion, by M. L. Ranvier. In wounds caused by cutting the cornea of the rabbit, two modes of closing up of the tissue can be noted, an immediate synaptic joining, and a true immediate joining, the former due to the cuts being filled with epithelial cells arising from the neighbouring epithelium, and the latter noticeable only in wounds forty-eight hours after the incision had been made, and where, owing to the lips of the cut happening to touch, no epithelial cells had penetrated.—The enlargement of the right auricle of the heart during inspiration demonstrated by radioscopy, by M. Ch. Bouchard.—On the fourth voyage of the *Princesse-Alice*, by S.A.S. Albert I., Prince of Monaco. The chief work was done on the western coast of Morocco, round Madeira and the Azores, and comprised sounding operations, together with zoological study of the fauna of the Princesse-Alice bank. A chart of this bank accompanies the paper.—Remarks by M. Edmond Perrier on his work on animal colonies and the formation of organisms.—Shooting-stars in the months of November and December 1897, observed at Basse-Terre (Guadeloupe), by M. Ch. Duprat.—On the development of uniform or holomorphic functions in any field, by M. Paul Painlevé.—On the types of increase and on complete functions, by M. Émile Borel.—On systems of partial differential equations analogous to equations of the first order, by M. Jules Beudon.—On the geometry of magnetic fields and of motion with two degrees of freedom in a plane or on a sphere, by M. René de Saussure.—Law of deformation of commercial metals, by M. Marcel Brillouin. A mathematical expression is given which includes all the known facts regarding permanent changes of shape in metals.—On an interference spectroscope, by MM. Ch. Fabry and A. Perot. The method consists in observing rings produced by transmission through a layer of air contained between two perfectly parallel silvered glass faces. Full details of the adjustments necessary are given in the present paper.—On the part played by diffraction in the effects produced with gratings, by M. Ch. Féry.—Study of chemical and physical equilibria by the osmotic method, by M. A. Ponsot.—On the law of mixture of gases, by M. Paul Sacerdote, giving the experimental results of mixing equal volumes of gases. The observed changes of pressure for a mixture of nitrous oxide and carbon dioxide, and of the latter gas with sulphur dioxide, are compared with those deduced from the densities by M. Leduc. The results of the two methods are in general agreement.—On the separation of thorium and the cerite earths, by MM. G. Wyrouboff and A. Verneuil.—The method proposed is based upon the fact that in a mixture of nitrates of the rare earths, as free as possible from excess of acid, heating with excess of hydrogen peroxide to 60° completely precipitates all the thoria in the solution.—Hydramides and the isomeric glyoxalidines, by M. Marcel Delépine. A thermochemical paper.—Researches on ouabaïne, by M. Arnaud.—Synthesis of terebic acid, by M. E. E. Blaise.—Manufacture of acetone oil, in particular of methyl-ethyl-ketone, by means of the liquors from the desuintage of wool, by MM. A. and P. Buisine. The calcium salts of the mixture of fatty acids obtained from wool is submitted to dry distillation. The resulting liquid yields on fractionation 60 per cent. of methyl-ethyl-ketone. —On the estimation of gastric juice, by M L. Cordier. The free acid is converted into lithium chloride by treatment with lithium carbonate, and this separated from the sodium chloride by extracting the incinerated residue with a mixture of equal parts of absolute alcohol and dry ether, in which the lithium chloride only is soluble.—Ergographical experiments for measuring the maximum power of a muscle regularly stretched, by MM. André Broca and Charles Richet.—The fungus *Sporotrichum globuliferum*, by M. Trabut.—On the anhydrous calcium sulphate produced by the complete dehydration of gypsum, by M. A. Lacroix. The dehydration of gypsum gives rise to a calcium sulphate dimorphous with anhydrite, probably triclinic. When the drying was not quite carried to completion another form of crystal was observed, possibly $2CaSO_4.H_2O$.—On the Callovian of Woëvre, by M. René Nicklès.—On the third international ascent of experimental balloons, by M. Ed. Stelling. Two ascents were made, one with two observers, the other balloon carrying self-registering instruments only. The temperature variation with the height is given in full.

DIARY OF SOCIETIES.

THURSDAY, FEBRUARY 3.

ROYAL SOCIETY, at 4.30.—Comparison of Oxygen with the Extra Lines in the Spectra of the Helium Stars β Crucis, &c.; also Summary of the Spectra of Southern Stars to the 3½ Magnitude and their Distribution: F. McClean, F.R.S.—Researches in Vortex Motion. Part III. On Spiral or Gyrostatic Vortex Aggregates: Prof. W. M. Hicks, F.R.S.—The Pharmacology of Aconitine, &c., considered in relation to their Chemical Constitution: Prof. Cash, F.R.S., and Prof. Dunstan, F.R.S.—Note on the Experimental Junction of the Vagus with the Cells of the Superior Cervical Ganglion: Dr. J. N. Langley, F.R.S.

ROYAL INSTITUTION, at 3.—The Halogen Group of Elements: Prof. J. Dewar, F.R.S.

LINNEAN SOCIETY, at 8.—On the Muscular Attachment of the Animal to its Shell in some Fossil Cephalopoda (Ammonoidea): G. C. Crick.—The Comparative Anatomy of certain Genera of Cycadaceæ: W. C. Worsdell.

CHEMICAL SOCIETY at 8.—Effect of the Mono-, Di-, and Tri-chloracetyl Groups on the Rotatory Power of Methylic and Ethylic Glycerates and Tartrates: Percy Frankland, F.R.S., and Dr. Thomas Stewart Patterson.—The Rotation of Ethylic and Methylic Di-monochloracetyltartrates: Percy Frankland, F.R.S., and Dr. Andrew Turnbull.—The Volumetric Estimation of Sodium: H. J. H. Fenton.

FRIDAY, FEBRUARY 4.

ROYAL INSTITUTION, at 9.—Some New Studies in Kathode and Röntgen Radiations: A. A. Campbell Swinton.

GEOLOGISTS' ASSOCIATION, at 7.30.—Annual General Meeting.—Palæolithic Man: E. T. Newton, F.R.S., President.

SATURDAY, FEBRUARY 5.

ROYAL INSTITUTION, at 3.—Cyprus: Prof. P. Geddes.

MONDAY, FEBRUARY 7.

SOCIETY OF CHEMICAL INDUSTRY, at 8.—The Curing of Malt in relation to Colour and Value: J. W. Lovibond.—Clerget's Method of Estimating Cane Sugar: A. R. Ling.—A New Modification of Clerget's Method of Estimating Cane Sugar, specially applicable to Molasses and After Products: A. R. Ling and J. T. Baker.—Note on the Estimation of Water in Invert Sugars: Dr. L. T. Thorne and E. H. Jeffers.

TUESDAY, FEBRUARY 8.

ROYAL INSTITUTION, at 3.—The Simplest Living Things: Prof. E. Ray Lankester, F.R.S.

ROYAL HORTICULTURAL SOCIETY, at 3.—Annual General Meeting.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Security of Locomotive Fire-Boxes: William Thow.—Friction of Locomotive Slide-Valves: John A. F. Aspinall.

ROYAL VICTORIA HALL, at 8.30.—The Problem of the Great African Lakes: J. E. S. Moore.

WEDNESDAY, FEBRUARY 9.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Notes on the Electro-Chemical Treatment of Ores containing the Precious Metals: Major-General Webber, C.B.—An Electrolytic Process for the Manufacture of Parabolic Reflectors: Sherard Cowper-Coles.

SANITARY INSTITUTE, at 8.—Purification of Water for Barracks, Prisons, and other Institutions: Prof. J. Lane Notter.

THURSDAY, FEBRUARY 10.

ROYAL SOCIETY, at 4.30.—*Probable Papers:* Contributions to the Theory of Alternating Currents: W. G. Rhodes.—The Development and Morphology of the Vascular System in Mammals. I. The Posterior End of the Aorta and the Iliac Arteries: Prof. A. H. Young and Dr. A. Robinson.—Further Observations upon the Comparative Chemistry of the Suprarenal Capsules: B. Moore and Swale Vincent.

MATHEMATICAL SOCIETY, at 8.—The Transformations which leave the Length of Arcs on any Surface Unaltered: J. E. Campbell.—On Aurifeuillians: Lieut.-Colonel Cunningham, R.E.

INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—Report of the Council.—Discussion upon Mr. Philip Dawson's Paper on Mechanical Features of Electric Traction.

FRIDAY, FEBRUARY 11.

ROYAL INSTITUTION, at 9.—The Metals used by the Great Nations of Antiquity: Dr. J. H. Gladstone, F.R.S.

ROYAL ASTRONOMICAL SOCIETY, at 3.—Annual General Meeting.

PHYSICAL SOCIETY, at 5.—Annual General Meeting.—Address by the President.—Also Paper: On Electromagnetic Induction in Plane, Cylindrical, and Spherical Current Sheets, and its Representation by Moving Trails of Images: Prof. G. H. Bryan, F.R.S.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Protection of Power Transmissions from Lightning: John T. Morris.

INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—First Report to the Gas-Engine Research Committee: Description of Apparatus and Methods, and Preliminary Results: Prof. Frederic W. Burstall.—Steam Laundry Machinery: Sidney Tebbutt.

MALACOLOGICAL SOCIETY, at 8.

BOOKS, PAMPHLET, and SERIALS RECEIVED.

BOOKS.—Introduction to Chemical Methods of Clinical Diagnosis: Dr. H. Tappeiner, translated by Dr. E. J. McWeeney (Longmans).—Annuaire de l'Observatoire Royal de Belgique, 1898 (Bruxelles).—Lehrbuch der Gesammten Wissenschaftlichen Genealogie: Dr. O. Lorenz (Berlin, Hertz).—A Text-Book of Zoology: Profs. Parker and Haswell, 2 Vols. (Macmillan).—Mensuration, Hydrostatics, and Heat: G. H. Wyatt (Rivingtons).—Chemical Experiments: G. H. Wyatt (Rivingtons).—The Mathematical Theory of the Top: Prof. F. Klein (New York, Scribner).—Glass-Blowing and Working: T. Bolas (Dawbarn).—Report of the Commissioner of Education for the Year 1895-96, Vol. 2 (Washington).—Lose Blätter aus Indien. ii. (Batavia, Albrecht).—Arbeiten des Physikalischen-Chemischen Instituts der Universität Leipzig aus der Jahren 1887 bis 1896, Bd. 1 to 4, Herausgegeben von W. Ostwald (Leipzig, Engelmann).—Explosifs Nitrés: J. Daniel (Paris, Gauthier-Villars).—Observations and Researches made at the Hong Kong Observatory in the Year 1896: W. Doberck (Hong Kong).

PAMPHLET.—Old Age Pensions: W. Birkmyre (Glasgow, Aird).

SERIALS.—Geological Survey of Canada, Annual Report, Vol. 9: Pts. F. and S. (Ottawa).—Good Words, February (Isbister).—Sunday Magazine, February (Isbister).—Botanische Jahrbücher, &c. Vierundzwanzigster Bd., 3 Heft (Berlin, Engelmann).—National Review, February (Arnold).—Century Magazine, February (Macmillan).—Record of Technical and Secondary Education, January (Macmillan).—Contemporary Review, February (Isbister).—Bulletin de l'Academie Royale des Sciences, &c., de Belgique, 1897, No. 12 (Bruxelles).—Terrestrial Magnetism, December (Cincinnati).

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