

THURSDAY, JUNE 25, 1891.

EDUCATIONAL ASPECTS OF FREE
EDUCATION.

AN innocent outsider would naturally suppose that the discussion on a proposal for free education would turn chiefly on educational and social considerations. So long as the question was of merely academic interest, this was, to a large extent, the case. It is true that strong Churchmen viewed with distaste a change which might increase the growing difficulty, found by voluntary school managers, of making both ends meet, or might possibly even sweep them off the board altogether, and that the enthusiasm of many partisans on the other side for the remission of fees was heightened by the hope that such a measure would give a new impetus to the formation of School Boards. But, on the whole, the disputants made at least an attempt in public to discuss the matter in its bearings on the child, the teacher, and the parent. The overburdened parent, the pauperizing effect of partial remission, the child kept from school because of his parents' poverty, the teachers converted into tax-collectors—these were the stage properties of the one party; while the stock-in-trade of the other side included the sacred necessity of guarding "parental responsibility," and the assertion that no one values what he does not pay for, and that to tax the hard-earned savings of the respectable middle-class to free the education of the children of the worthless and unthrifty was a Socialistic proposal of the crudest kind.

We now find that most of this talk was pure cant. It ceased to be heard from the moment when free education became a practical party question. To outward appearance the contest over the Bill has become a kind of Jerusalem race—everyone wishing to leave to someone else the unpleasant task of formulating the criticisms with which he secretly sympathizes, but to which fear of his constituents prevents him from giving utterance.

If we could induce the parties to break through this conspiracy of agreement, we should find that, with a few exceptions, the point on which the advocates feel most keenly is the possibility of using the Act as a lever either to destroy or to perpetuate for ever the voluntary school system. In spite of the apparent calm, the battle between the supporters of School Boards and voluntary schools is raging fiercely below the surface; and most of the amendments put down for the Committee stage are certain to represent attempts, more or less open or disguised, to wrest the provisions of the Act to suit the purposes of one or the other party.

It must be confessed that this is to a great extent natural. The Act of 1870 was a compromise: the present Bill virtually reopens the question, and it is felt that, whatever be the logic or want of logic in the argument that Imperial grants should involve local control, the time when large additional grants are being made to voluntary schools is the time, *if ever*, to drive home the question of popular management. We do not, then, quarrel with those who feel that the opportunity must not be lost of raising this question; indeed, we should respect them more if they raised it more openly. But we do

protest against the almost total omission of all educational considerations in the arguments used on both sides.

It is time that the third party to the dispute—the real friends of education—made themselves heard. Their one object is to see that the educational benefits of the measure should be maximized, and the incidental evils minimized. They ask what is to be demanded in the shape of increased efficiency in return for a new grant of £2,000,000 to school managers. Is a great part of it to be allowed to be absorbed by the reduction of private subscriptions and rates, or is it to be used to improve the children's education, and make it a better preparation for their future industry?

In the rural districts, the grant in lieu of fees will almost universally be in excess of the income now received from fees. There will therefore be a surplus in the hands of the managers, or manager—for very often these schools are in the hands of one man. Where will this surplus go? In our opinion some method ought, if possible, to be found of "ear-marking" it for education rather than for subscribers' pockets. If this were done, nearly the whole of the rural schools of England might be raised in character. It would be possible, for example, to introduce, with the aid of the new surplus, some simple teaching in agricultural subjects, such as is recognized in the Code, but is at present a dead letter; for the increased grant would be quite enough to pay a competent travelling teacher to give such instruction in a group of schools. If there were universal county or district school authorities, it might be well to hand over the surplus grant into their hands, to be used solely for the improvement of the various schools on whose account it was paid. As, unfortunately, our organization is piecemeal, we are forced to deal direct with each school, and we can therefore only appeal to public-spirited managers to take care that the children for whose education they are responsible reap the full advantage of every penny which they receive over and above the present fees charged. It is to be feared, however, that in many cases the managers are at the mercy of their subscribers, and many of them would probably now welcome the proposal made by the Bishop of London, but foolishly rejected by his clerical friends on the late Royal Commission—that a certain minimum of private subscriptions should be required by law in the case of every voluntary school. If such a provision were in force, school managers in the country would be saved many anxious forebodings at the present time.

The second point in the Bill on which educational reformers should fix their attention is the limitation of the benefits to children between five and fourteen. The lower limit need not trouble us, and may be left to be worried by the "poor man's" numerous friends. But the upper limit should be resolutely opposed. It is quite true that at the present time it is of comparatively little importance—only affecting some few thousands of children. But if one of the great objects of educational policy is to lengthen the period of school life, the handful of children at elementary schools above fourteen should certainly not be fined for staying there; if anything, they should receive scholarships to enable them to do so. In our opinion, moreover, ex-seventh standard children (who are not for the most part touched by the present Bill) should be also admitted free, or at least sufficient

scholarships should be provided to enable any poor child who has passed the standards to continue his education either in the school or elsewhere. We do not say that such scholarships should be universally provided out of the present grant, but they would be a most proper object to which to apply part of the surplus which will be handed to many schools over and above the fee equivalent. These considerations suggest another possible way of dealing with the surplus grants. The great object of those who are interested in the development of higher elementary, technical, and secondary education should be to strengthen instead of weakening the connection between primary and higher schools. It is to be feared that any provision for freeing elementary schools up to a certain point or a certain age, will tend to sever rather than to unite the two grades of schools, unless the flow between them is at the same time stimulated by the establishment of free scholarships or in other ways. A free (or partly free) elementary school is not the ultimate ideal. We want a free road kept open to the University. Is it too late to throw out the suggestion that school managers receiving a fee-grant in excess of the amount previously received in fees should be required to use the surplus for an object akin to that contemplated by the main provisions of the Bill—viz. the extension of free education for selected scholars beyond the narrow limits of the primary schools, in other words the provision of continuation scholarships? Up to a short time ago it would have been replied that in many cases there were no higher institutions accessible, but the application of the Local Taxation grant to technical and secondary education is fast changing all that, and a proposal which a few years since would have been unfeasible is now well within the range of practical politics.

DIFFERENTIAL AND INTEGRAL CALCULUS.

Differential and Integral Calculus, with Applications.

By Alfred George Greenhill, M.A., F.R.S. Second Edition. (London: Macmillan and Co., 1891.)

PROF. GREENHILL is known to the academic world as an accomplished mathematician who has powerfully helped to advance certain branches of applied mathematics; he is also known to the readers of NATURE as a friend (militant) of the practical man. We say at once, in all sincerity, that we sympathize with Prof. Greenhill in both his capacities. The volume on the infinitesimal calculus now before us, although professedly a second edition, is in reality a new work, addressed to the special needs of the practical man by his mathematical friend Prof. Greenhill.

Of many of the author's didactic innovations we highly approve. The treatment of the differential and integral calculus together from the very beginning is a piece of sound method, the introduction of which has been delayed merely by the bad but not infrequent practice of separating the two as examination subjects. The introduction of the hyperbolic functions to systematize the integrations which can be performed by means of the elementary transcendents, has been, as we can testify from experience, a great help in elementary teaching. The admirable "chapter in the integral calculus" which was published separately

in an extended form some years ago, and is now condensed and simplified in a separate chapter at the end of the work under review, is the most important addition to the teaching material of the integral calculus that has been made for a long time; that chapter alone is worth the price of Prof. Greenhill's book. The plan of drawing the illustrations of the subject from departments of pure and applied mathematics with which the learner may afterwards have to do is also excellent. Finally, there blows through our author's pages that inimitable freshness which emanates from the man who is familiar with much that is newest and best in his day, who does not merely make extracts from books, but who speaks of things in which he has taken a part. This freshness can only be compared to that agreeable odour which inland people tell us comes from mariners and others who cross the sea from strange lands. Like these same mariners, our author produces from his pockets strange and puzzling curiosities, such as reciprocants, tide predictors, Schwarzian derivatives, Mehler's functions, to delight and to dazzle the learner. It is true he tells but little of these things; still, it is pleasant to look at them; and they make us happy under our present toil by leading us to think that we too may one day visit the country where these pretty things are at home amidst their proper surroundings.

Where there is so much to praise we are truly sorry to insinuate the bitter drop of blame; but, much as we love and follow Plato, something must be conceded to truth. In the first place, we think that in this second edition the introduction of heterogeneous illustration has been overdone. The fundamental rules of the infinitesimal calculus are really very few in number, and the practical man's friend would do well to impress that upon him at the outset, instead of scattering these principles through a large volume, and overlaying them with thick masses of disconnected application, to such an extent that poor Mr. Practical-Man is in danger of losing his tools among the shavings, or, to use a metaphor which Prof. Greenhill's pupils might prefer, of not seeing his guns for smoke. Prof. Greenhill must recollect that the man that sits down to read his book is not all possible practical men rolled into one, but *one* poor practical man—say, an engineer—who wants some knowledge of the infinitesimal calculus, and who will find many of the illustrations more indigestible than the principles of the calculus itself. Would it not be better for the practical man, as well as for any other man, to have the few leading principles of the calculus set before him with an adequate but moderate amount of illustration of a uniform geometrical kind, and not to be dazed by a flood of oracular statements about soap-bubble films, tide-predictors, &c., in the course of his initiation? Such digressions are most useful now and then in a lecture; they serve to give picturesqueness to the discourse, and help to fix the attention of the hearer: but we think that too many of them destroy the usefulness of a text-book, the object of which is quite different from the purpose of a lecture.

The matter we have just been criticizing may, perhaps, be held to be one of taste; and we cheerfully admit that much should be allowed to a writer of strong individuality. After all, we love to have the author in his book. There is another matter, of more importance, on which we

would appeal to Prof. Greenhill. When a man, so able and unconventional as he, writes a book of 455 pages on the infinitesimal calculus, is it too much to expect that he will everywhere give a thorough discussion of its few fundamental principles, that he will rigorously prove what he professes to demonstrate, and honestly point out what he assumes without demonstration? We certainly expect him to root out of the subject every trace of the sham demonstration—that wily artifice of the coaching and examining days of our dear old *alma mater*—which used sometimes to be dignified by the name of the “short proof.” This used, to be employed when we had on hand the establishment of some proposition which was not universally true (although usually so enunciated), or which had exceptions too tedious to enumerate in an examination. The method was to make a kind of *précis* containing as few words of intelligible English as possible, but a considerable sprinkling of ingeniously constructed but unexplained symbols and formulæ; so that an examiner of average conscience, suspecting that the truth was not there, might nevertheless, without mental distress, make believe that it *was* there, and award the coveted marks.

We complain that Prof. Greenhill should countenance the slipshod exposition of elementary principles which is the bad feature of so many of our English mathematical text-books. Having started his furrow, he should have ploughed to the end. He may retort that he has adhered to the traditional usage out of consideration for the weakness of the practical man, who abhors sound logic quite as much as his academic brother. Cruel consideration for the practical man! for what *he* wants above all is a firm grasp of the fundamental principles of the calculus; he has rarely any use for the analytical house of cards, composed of complicated and curious formulæ, which the academic tyro builds with such zest upon a slippery foundation.

It would take up too much of the columns of NATURE to give all the examples that might be adduced of the laxity we complain of. A few must suffice. We are told in § 1 that the “calculus to be developed is the method of reasoning applicable to variable quantities in a state of continuous change;” yet no definition or discussion of “continuity” is given: the word, so far as we can find, does not occur again in the first chapter, although it is the keynote of the subject. “Newton’s microscope,” for example, is quoted in § 9, as a proof of the theorem $Lt(\text{chord}/\text{arc}) = 1$; but the essential condition, “in medio curvaturæ continuæ,” which makes it a proof (if proof be the word that describes its purpose) is omitted. Although the differential calculus is merely a piece of machinery for calculating, and calculating with limiting values, a limiting value is not defined; nor is there any discussion of the algebra of limiting values—a matter which has puzzled beginners in all ages, and which has stopped many on the threshold of the calculus. It is true that we are referred to Hall and Knight’s “Algebra,” but what we find there is little to the purpose, and certainly could never have been meant by its authors as a foundation for the differential calculus.

In § 16 we are given a quantity of elementary instruction, in the middle of which the trigonometrical functions are inadequately defined; but nothing adequate is said

regarding the sense in which the many-valued functions $\sin^{-1}x$, $\cos^{-1}x$, &c., are continuous: and in § 25 the beginner is led by implication to believe that $d(\sin^{-1}x)/dx$ is always $+1/\sqrt{1-x^2}$, and $d(\cos^{-1}x)/dx$ always $-1/\sqrt{1-x^2}$; although this is not so, and the point is one that is of the greatest importance in the integral calculus, and is a standing rock of offence for learners. In § 28 we have, reproduced “for the sake of completeness,” the time-honoured “short proof” of the existence of the exponential limit, which proof is half the real proof *plus a suggestio falsi*. If the proper proof (a very simple matter) was thought too much for the reader, then it would have been better simply to tell him the fact, and not to corrupt his intellectual honesty by demanding his assent to a piece of reasoning which is not conclusive. § 31 is no better; what, for instance, *does* Prof. Greenhill mean, after proving that $\exp n = e^n$, where n is a positive integer, by saying, “and thence generally by induction, $\exp x = e^x$ for all values of x .” It would scarcely be possible to write down a statement to which more exceptions could be taken unless “induction” is a misprint for “assumption.”

The chapter on the expansion of functions is not satisfactory. We are first introduced to “a general theorem called *Taylor’s theorem*, by means of which any function whatever can be expanded [in ascending powers of x].” Prof. Greenhill knows as well as we that there is no such theorem. No theorem ever to be discovered will expand in ascending powers of x , $1/x$, \sqrt{x} , $\log x$, or any function which has $x = 0$ for a critical point. Why does our author hide his light from the reader? Does it make the apprehension of Taylor’s theorem any easier to enunciate it falsely? We are told in § 114 that “some functions, for instance $\sec^{-1}x$, cannot be expanded in an infinite series in ascending powers of x , because x must be greater than unity, and the expansion by Taylor’s or Maclaurin’s theorem would be *divergent*, and the theorem is then said to fail.”

“This difficulty will be avoided if we can make the series terminate after a finite number of terms.”

We would not advise the practical man to try to overcome the difficulty of expanding $\sec^{-1}x$ by the method thus indicated (use of Maclaurin’s theorem with the remainder), because the result might be that the bond of amity struck in the preface between him and the author would be broken. All the king’s horses and all the king’s men will not get over this difficulty. Incidentally we are told in § 112 that a rigorous proof is given in treatises on trigonometry of the resolution into factors of $\sin \theta$ and $\cos \theta$. If standard English treatises, such as Todhunter, Locke, and Johnson, are meant, this is not true: the demonstrations they give are unsound. Mr. Hobson’s article on trigonometry in the “Encyclopædia Britannica” is the only separate English treatise on trigonometry of which we are aware where a sound proof can be found.

When so many novelties of less importance are noticed, surely our author might have found a place for a reference to the theorem that puts the expansibility of a function in ascending powers of x in its true position, viz. Cauchy’s theorem that every function is so expansible within a certain region surrounding $x = 0$, provided $x = 0$ be not a critical value. Considering the great importance

of the fact, and its close connection with the applications of mathematics to physical problems, some mention might have been made of the importance of the critical points of a function in determining its value. A full discussion of such things is doubtless impossible in an elementary treatise; but the reader should at least be warned that what is given regarding the expansion of functions in power-series is a mere fragment of what is known on the subject. The tendency of Prof. Greenhill's chapter on the expansion of functions certainly will be to suggest to the mind of a beginner wrong general notions on the subject.

In § 126 we have two proofs given that

$$\partial^2 f(x, y) / \partial x \partial y = \partial^2 f(x, y) / \partial y \partial x,$$

both of them insufficient; for the one rests on the assumption that $f(x+h, y+k)$ can always be expanded in an integral h - k -power-series, the other on the assumption that

$$\int_{h=0}^L \int_{k=0}^L \chi(h, k) = \int_{k=0}^L \int_{h=0}^L \chi(h, k),$$

both of which propositions are liable to exception.

In the discussion of single and double integrals, no hint is allowed to reach the reader of the necessity of convergency as a condition of their having any meaning at all, of the precautions that must be observed in differentiating them, or in altering the order of integration, and so on. Still, the reader is given a proof of Green's theorem. What use this is likely to be to one ignorant of the fundamental character of the convergency and discontinuities of multiple integrals, upon which many of the most important applications of the theorem in question depend, it is not easy to see. Too much of the work before us bears, in fact, the character of a hurriedly written *précis* or syllabus of lectures; witness, for example, the oracular character of §§ 146, 151, 152, &c. Our author makes enormous demands on the intelligence of a beginner if he expects him to follow and understand exposition so elliptical.

One more example of the thing we complain of. In § 183 we are introduced to Fourier's series. No proof is given (none was to be expected in an elementary treatise) of the conditions under which the expansion is possible, but it ought to have been stated that there are such conditions. Moreover, the method given for the determination of the coefficients is a mere *memoria technica* for recollecting them. It has no demonstrative force, because, as the author must be very well aware, it is not unconditionally allowable to replace the integral of an infinite series (even if it be convergent) by the sum of the integrals of its separate terms. In order that this may be admissible, the series must be *uniformly* convergent.

Seeing that the world is very evil, and not to be mended in a day, we must put up with such things in the ordinary writer of English text-books, who caters for the victims of our manifold examinations; but in a pillar of mathematical society like Prof. Greenhill they are "most tolerable and not to be endured." A work with his name on its back, and the impress of his vigorous personality on its pages, will not remain long in a second edition. If he would be at once the friend of the practical man, and a well-deserver of the mathematical republic, let him, when the third edition is called for, reduce his elementary work to

the compass of the first edition or less, and replace all half demonstrations by honest statements of fact; and let him, meantime, write a larger work, to which he can refer the elementary reader who takes for his motto, "*Thorough.*"

G. C.

THE GEOLOGY OF THE COUNTRY ROUND LIVERPOOL.

Geology of the Country around Liverpool. By G. H. Morton, F.G.S. Second Edition. (London: Philip and Son, 1891.)

IN this work Mr. Morton has entirely re-written the "Geology of the Liverpool District," first published in 1863, by the light of the various discoveries made since that time, and especially of the Geological Survey maps and memoirs. He has succeeded in making a compact and well-printed hand-book, which will be of great service to the students of the local geology. The area described extends to about 20 miles from Liverpool on every side, excepting the sea on the west. The strata which he describes range from the Upper Silurians of the Vale of Clwyd through the Carboniferous, Permian, and Triassic rocks, down to the recent alluvia. To a geologist the chapter relating to the Carboniferous rocks of North Flintshire and the Vale of Clwyd will be of great interest, as it shows the thinning off of the strata as they approach the ancient Carboniferous land of North Wales. The Carboniferous Limestone, over 3000 feet thick in North Lancashire, is reduced to 1700 feet in North Flint and the Vale of Clwyd; while the Yoredales and Millstone Grits, over 9000 feet thick between Clitheroe and Burnley, are represented by the Cefn-y-Fedw Sandstone, 370 feet. The Lower and Middle Coal-measures, too, of South-West Lancashire, 3180 feet thick, have dwindled down to no more than 1000 feet as they approached the Welsh Silurian Hills. It is therefore obvious that the Snowdonian area was dry land while the Carboniferous sea occupied the areas of Lancashire, Derbyshire, and Cheshire, and that it also overlooked the forest-covered morasses, now represented by the coal-seams of the same region in the Upper Carboniferous age. In the table of the rocks (p. 6) Mr. Morton gives 300 feet as the thickness of the Millstone Grit in South-West Lancashire. It is probably much more than this, and not much less than 2000 feet. Mr. Morton also, we may remark, understates the thickness of the Keuper Marls, which he puts down at 400 feet (p. 75). In the Lancashire and Cheshire plain it is 700 + feet, and is estimated by Prof. Hull at 3000 feet.

Mr. Morton, in dealing with the deep boring at Bootle, made in 1878, under the advice of the writer of this review, is mistaken in supposing that it was aimed at the water in the Permian Sandstone. It was intended to strike the water in the Lower Bunter Sandstones, and to draw upon the enormous area of water-bearing strata in the Lancashire and Cheshire plain, which have their outlet seawards between Prescot and the estuary of the Dee. It is very likely that the Permians are not represented under Liverpool. We expected to strike the Coal-measures at 1000 feet. The boring was successful, both from the geological and the engineering point of view. It proved that the Lower Bunter Sandstones below the top

of the Upper Pebble-beds are more than 1300 feet thick, and that they are highly charged with water. This thickness is altogether without precedent, and Liverpool is to be congratulated upon being built upon so great a thickness of water-bearing Triassic rocks. Mr. Morton, should the work reach another edition, would do well to deal at greater length with the water-supply available from the Triassic strata. Mr. Boulton has tabulated the well-sections, and all students of the geology of Liverpool would do well to examine his valuable tables.

We would call special attention to Mr. Morton's section—unfortunately, the work is not divided into chapters—on the origin of the estuary of the Mersey. While the river has been draining its present watershed from a period far more remote than the Pleistocene age, he holds that the estuarine portion is comparatively modern, dating probably not further back than post-Roman times. It would not, he argues, following Sir James Picton, have been neglected by the Romans, if it had then “presented the copious body of water which it does at the present day.” There is no evidence that they did neglect it. The Manchester Ship Canal works have revealed the existence of Roman remains, probably the Veratinum of the anonymous geographer of Ravenna, on the banks of the Mersey close to Warrington, and Mancunium (Manchester) is on one of its tributaries. They used it, as they used all the rivers of Britain, for their own ends. Deva (Chester), the great port, and military centre of the north-west, was not far off, and amply sufficient for the western trade at a time when there were no ports in Ireland. The commercial importance of the Mersey is solely due to the trade with the New World. There was no reason why the Romans should have paid special attention to the estuary of the Mersey; and it was outside the system of their roads. Nor can the date, 1279, of the great inroad of the sea over the Stanlow Marshes, by which the Abbey of Stanlow, built upon a rock only 28.5 feet above O.D., lost much of its land, be taken as evidence of the modern formation of the estuary. The river swings to and fro at the present time, depositing silt here, and carrying away its banks there. In our opinion, therefore, the post-Roman origin of the Mersey is not proved. It is still less likely that it is the result of a local submergence, which has not affected Warrington and the adjacent area of Chester. As the evidence stands, the date of the estuary of the Mersey belongs to the same remote prehistoric period as the estuary of the Thames and of the Humber—certainly after the time of the boulder clays, and probably long before there were any written records in Britain. All three are later than the time of the submarine forest which, on the west of Britain, afforded shelter, not merely to our Neolithic ancestors, but to their domestic animals, such as the small short-horn (*Bos longifrons*), the goat, and the dog.

W. BOYD DAWKINS.

OUR BOOK SHELF.

Les Microbes, les Ferments, et ses Moisissures. Par le Dr. E. L. Trouessart. Deuxième Edition. Bibliothèque Scientifique Internationale. (Paris, 1891.)

This is not only an enlargement but a distinct improvement on the first edition. Chapters i. and ii., as in the

first edition, give an excellent though short account of the morphology and physiology of fungi and of yeast. Although chapter iii. (on bacteria) is enlarged, we do not think it is sufficiently up to date; thus, for instance, on pp. 74 and 75, the author questions the existence of true flagella in bacteria, and states that their motility is essentially different from that of flagellate infusoria. Again, in the section in which putrid decomposition is described no mention is made of the entire tribe of Proteus, the essential microbe of putrefaction.

Chapters iv. and v. (pathogenic bacteria) are considerably enlarged, both as to text and illustrations. The rest of the book, chapters vi.-ix., does not differ in any essential respect from its predecessor.

On the whole, the book is very commendable as a concise text-book, well written and copiously illustrated, and as such deserves a high place in the literature of the subject.

Botanical Wall Diagrams. Size 31½ inches by 24 inches, printed in colours. (London: Society for Promoting Christian Knowledge, 1891.)

A FIRST instalment of six of these diagrams is now published. The plants illustrated so far are: common elder, deadly nightshade, scarlet runner, hop, Virginia tobacco, and wild camomile. We do not know on what principle the selection has been made. It is rather a pity that, out of so small a number, two (deadly nightshade and tobacco) belong to the same natural order, and show no very essential structural differences. In time we hope that all the important orders will be represented. The drawings (executed by Engleder, of Munich) are quite artistic, and the colouring excellent. The diagrams are thus very pleasing as pictures, and at the same time the botanical details are correct.

If the series is continued as well as it has been begun, it ought to be a very useful help in the elementary systematic teaching of botany. D. H. S.

Chambers's Encyclopædia. New Edition. Vol. VII. (London and Edinburgh: W. and R. Chambers, Limited, 1891.)

NO ONE who has had occasion to refer to the new edition of Chambers's "Encyclopædia" can have failed to appreciate the care and ability with which it is being prepared. The editor has been fortunate enough to secure the co-operation of many eminent writers, and the information given in the various articles, speaking generally, is well up to date and presented in the way most likely to be convenient for students. We are here concerned only with the papers on scientific subjects, and these, in the present as in the preceding volumes, are in every way worthy of the place which has been assigned to them in the scheme of the work as a whole. Prof. P. G. Tait contributes a short but masterly paper on matter, and Dr. Buchan gives a clear and interesting account of meteorology. The essential facts about the Mediterranean are compressed into very small space by Dr. John Murray, who also writes on the Pacific. Prof. James Geikie deals with mountains and palæontology, and Dr. Alfred Daniell has a good popular article on optics, devoted mainly to the history of optical science. In an article on man, Mr. J. Arthur Thomson states very well some of the problems relating to human characteristics, the origin or descent of man, and the antiquity of the race; and the same writer sketches the career of Pasteur, and treats of mammals and parasites. Mimicry forms the subject of an excellent paper by Mr. E. B. Poulton. Of course, no subject is treated exhaustively, but the information given, so far as it goes, is sound, and ample enough for the purposes for which an encyclopædia is usually consulted.

Glimpses of Nature. By Andrew Wilson. (London: Chatto and Windus, 1891.)

MR. WILSON does not profess to present in this book anything strictly new, or to give a full account of the various subjects with which he deals. Nevertheless, the volume may be of considerable value, for on all the groups of facts in which he is interested he is able to discourse brightly and pleasantly, and many of his short papers are well calculated to excite in the minds of intelligent readers a desire for more ample knowledge. The papers are reprinted from the *Illustrated London News*.

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 Fusing and Boiling Points of Compounds.

I HEREWITH send you the translation of a note just presented for me by M. Berthelot to the Paris Academy, as you may see in the *Comptes rendus*. I have added two illustrations and a few words in italics. GUSTAVUS HINRICH'S.
St. Louis, May 8.

Statement of the General Law determining the Fusing and Boiling Points of any Compound under any Pressure, as Simple Function of the Chemical Constitution of the same. By Dr. Gustavus Hinrichs.

The atomic form of normal lineary compounds, such as the paraffins, alcohols, acids, is very nearly prismatic. All other serial compounds may be referred to these, either as isomerics or

The boiling-point t of a prismatic compound consists of two distinct functions, namely—

$$t = y_1 + y_2 \dots \dots \dots (1)$$

where

$$y_1 = k_1(\log a - \log a_1) \dots \dots \dots (2)$$

and

$$y_2 = k_2(\log a_2 - \log a)^2 \dots \dots \dots (3)$$

The symbols a_1 and a_2 represent certain definite values of the atomic weight a of the compound, while k_1 and k_2 are constants.

For every value of the atomic weight a greater than a_2 the formula (1) is limited to $t = y_1$, which, according to (2), represents the straight line which I call the logarithmic limit, the ordinate being the boiling-point t , the abscissa x , the logarithm of the atomic weight $x = \log a$. For values of a less than the above limit a_2 , the parabolic ordinate y_2 , determined by (3), must be added to y_1 , according to (1), in order to obtain the boiling-point.

Accordingly, the boiling-point curve of any homologous series of prismatic atom-form consists of a parabolic arc (3), tangent to the logarithmic limit (2), at the point determined by $a = a_2$. The constant k_1 determines the inclination of the logarithmic limit, and k_2 may be called the parameter of the parabolic branch.

All compounds derivable by terminal substitution from normal paraffins have a common logarithmic limit, determined by $k_1 = 583^{\circ}75$ and $a_1 = 72^{\circ}78$, the pressure being 760 mm. Every individual homologous series of this great family of compounds is completely determined by the special values of the two constants a_2 and k_2 . For example, the thirty-five normal paraffins C_nH_{2n+2} are determined by $a_2 = 201$, and the parameter $k_2 = 200^{\circ}$. For the monamines, the corresponding values are $a_2 = 278$, and $k_2 = 225^{\circ}$. I have determined these constants for all the important series. Furthermore, these values are themselves functions of the atom or radical which characterizes the head of the corresponding homologous series—that is, H for the paraffins, H_2N for monamines, &c.

If now the co-ordinate $z = \log p$, where p is the pressure of

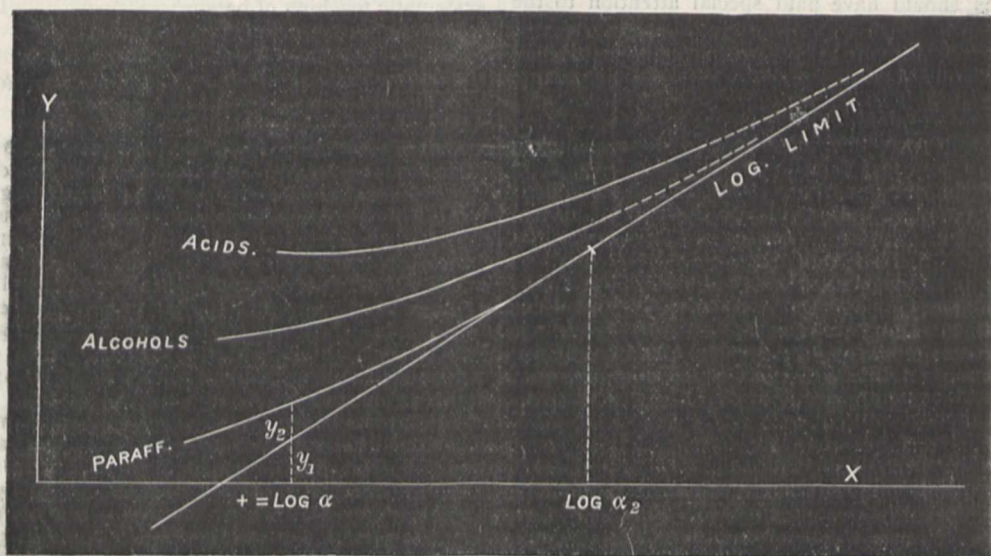


FIG. 1.

as substitution products. The boiling and fusing points of these latter are obtained from those of the former according to laws and processes published by me about twenty years ago, partly in my "Principles of Molecular Mechanics," 1874, and in Notes of the *Comptes rendus* for 1873 and 1875; partly in papers of the *Proceedings of the American Association for the Advancement of Science* for 1868. It remains, therefore, only to show how these fundamental points are determined for prismatic compounds.

the saturated vapours, be laid off on the third rectangular axis the above given values l along to the plane XY determined by $p = 760$ mm. For the pressure $p = 15$ mm. the logarithmic limit is determined by $k_1 = 517^{\circ}6$, and $a_1 = 113^{\circ}81$. It will be noticed that its inclination towards the X axis is less, and that it intersects the same at a greater distance from the origin. The logarithmic limit surface, generated by the logarithmic limits for all pressures, is a hyperbolic paraboloid, fully determined by the above two lines for 15 and 760 mm. pressure.

For any liquid, the absolute temperature T of the boiling under a pressure of p atmospheres is determined by the same general law slightly specialized as follows:—

$$T = Y_1 + Y_2 \dots \dots \dots (4)$$

where

$$Y_1 = K_1[1.4 + \log p] \dots \dots \dots (5)$$

and

$$Y_2 = K_2[\log \pi - \log p]^2 \dots \dots \dots (6)$$

The logarithmic limits of all liquids intersect in the same absolute zero point determined by $T = 0 = -273^\circ \text{C}$. and $\log p = -1.4$. For each individual liquid this limit extends upwards to the critical point of the liquid, $p = \pi$ and $T = \theta$. For many liquids the critical point can be theoretically calculated, as well as the value of the parameter. It is understood

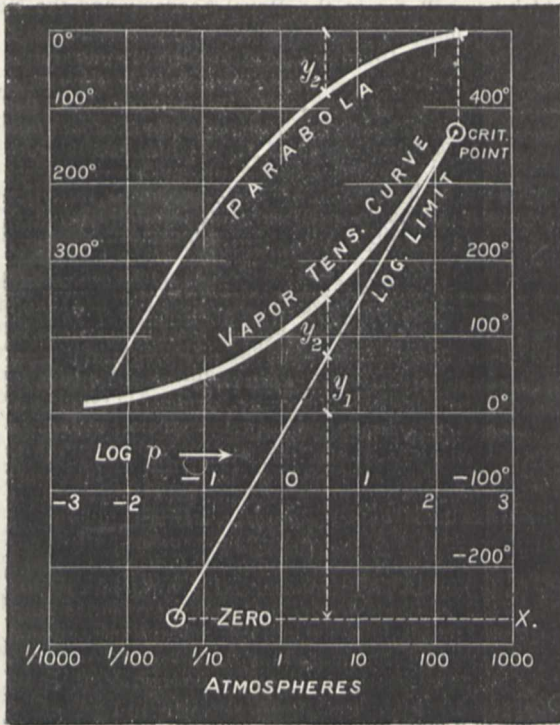


FIG. 2.

that the parabolic curve is tangent to the logarithmic limit at the critical point.

It hardly needs to be said that the tension of dissociation, and even the solubility of solids, are subject to the same general law.

The fusing points are obtained by simply changing the sign in (1) to

$$t = y_1 - y_2 \dots \dots \dots (7)$$

so that the parabolic curve will be placed below the logarithmic limit.

One of the most remarkable results of this research is the mechanical determination of the true position of the carbon atoms in organic serials, and the complete explanation of the difference in fusing point between compounds containing an even and odd number of carbon atoms.

It should also be understood that the change in fusing point produced by change in pressure is expressed by the same general law.

Putting $\log a = x$, $\log p = z$, and $\log \alpha = \xi$, $\log \pi = \zeta$, the formulæ (1) to (7) will become

$$t = y_1 \pm y_2, \quad y_1 = k_1(x - \xi), \quad y_2 = k_2(\xi - x)^2. \quad (8)$$

$$T = Y_1 + Y_2, \quad Y_1 = K_1(z - \zeta), \quad Y_2 = K_2(\zeta - z)^2. \quad (9)$$

These formulæ strikingly show the simplicity of the laws stated, and also determine the surfaces formed by the coordinates x , t , and y in general.

In subsequent notes special topics covered by this general law will be taken up, and the complete concordance of the law with the results of observations will be shown.

Porpoises in African Rivers.

IN reference to Mr. Sclater's letter in NATURE of June 11 (p. 124), the following may be interesting to your readers:—

The skull of a Delphinoid Cetacean from Cameroon has lately come into my hands, through the kindness of Prof. Pechnel-Loesche. The sender, Mr. Edward Tëusz, gave the following information concerning it. The animal to which it belonged was caught in Kriegschiff Bay, after very heavy rains, and was being devoured by sharks. The contents of the stomach consisted of grass, weeds, and mangrove fruits. None of the natives had ever seen the animal before. In preparing the skull, Mr. Edward Tëusz noticed that the nostrils projected above the surface of the forehead.

I am preparing for publication a detailed description of the skull, and must here confine myself to remarking that, though the animal belongs to the genus Sotalia, it differs in several essential points from all the species of that genus hitherto described. I have no doubt that it is a new species. There are twenty-seven teeth on each side in each jaw. Their form, in that they are not pointed, but worn down, indicates, as also do the contents of the stomach, that the animal is herbivorous. It therefore seems certain that it is a fresh-water animal. It is well known that other Sotalia live in rivers.

Jena, June 20.

WILLY KÜENTHAL.

*PHYSICAL SCIENCE FOR ARTISTS.*¹

I.

I THINK it right that I should begin by explaining how it is that I am here to-day, to lecture to you on a subject which touches art as well as science. It happens in this wise. Some years ago, while studying a certain branch of optics, it became important for me to try to learn something of the exact sequence of colours at sunrise and sunset; and being, like you, busy all day in a large city, I thought it would not be a bad idea, and that it would save a little time, if I studied pictures representing these phenomena *en attendant* the happy holiday time that I should spend in the country. So I went to the Academy and other picture galleries, and endeavoured to get up the information from pictures which I could not at that time get from Nature herself. I then had, as I have still, such an extreme respect for art and artists that I was perfectly prepared to take the pictures as representing truthfully what I wanted to see. The result, however, brought me face to face with a difficulty that I was not long in finding out. I was driven to the conclusion that artists could be divided into two distinct classes—those who studied Nature and Nature's laws, and gave us most exquisite renderings of this or that, and those who apparently considered themselves far superior to any such confining conditions as would be imposed by any law; and that, unfortunately, made me a little doubtful as to the results.

My friend, and your friend, Dr. Russell, happens to know this little bit of my experience, and hence it doubtless is that he requested me to come down to-day to say a few words to you, his plea being that this College is one of the very few institutions of its kind in the world where there is a studio and a physical laboratory side by side.

That, then, is the reason I am here, and what I want to impress upon you to-day is that the highest art can only be produced by those who associate the study of physical science with the study of art, and that therefore the possible producers of the highest art can only be looked for in such an institution as this if training of any kind has anything to do with it.

¹ A Lecture delivered at Bedford College, by J. Norman Lockyer F.R.S. on June 10, 1891.

I think that the *general* conditions of art training as they exist at present absolutely bar any sufficient knowledge of the laws and conditions of natural phenomena on the part of art students.

The *best* art of the time has always been on a level with the best science of the time, and if it had not happened that the first schools and the first Universities clustered round medical schools and schools of anatomy, I do not think that so much attention would be given to-day to anatomical science to the exclusion of all other branches.

You see, then, it comes to this. It is conceded by the art world that in a certain direction the phenomena of Nature require to be studied, otherwise that tremendously exuberant literature on Anatomy for Artists would not have been written, and more than half of the time of students of art would be spent in studying something else rather than those things which they do study.

It is on that ground that I would venture to say that in other institutions, as in this one, the study of physical science should be added to the other branches already recognized by the art world.

I am not an artist. I am not an art critic. I am almost unacquainted with the language usually employed by those who write on art subjects. I shall not deal with opinions, the algebraical sum of which in relation to the qualities of any one picture I have often noticed is zero; but what I shall try to do is to stick as closely as I can to the region of fact, and endeavour to show you, by two or three individual instances, how a student who wishes to become a great artist—as some of you no doubt do—will find his or her ambition more likely to be realized if the study of physical science be combined with that of “Art as she is taught” to-day.

In looking at the Academy Catalogue this year one finds the motto, “La mission de l’art n’est pas de copier la nature, mais de l’exprimer,” and this is a true motto. But let us analyze it a little. To “express” suggests a language; a language suggests a grammar, if it is to be perfect, satisfying. But what can this grammar be, in the case we are considering, but the laws underlying the phenomena the “expression” of which, in his own language, constitutes the life-work of the artist. Should he be content to show himself a bumpkin? Are solecisms to be pardoned in his expressions because, so far, scientific training and thought are so limited? Is he justified in relying upon the ignorance of mankind, and, if so, is the highest art always to remain divorced from the highest knowledge?

Now it so happens that the branch of physical science which is above all things the thing to be studied by artists, is the branch of it which is already familiar to you—namely, optics. There could be no art without light; no artists without light; and the whole work of an artist, from the beginning to the end of his life, is to deal with light. Now we live in a world of white light. We might live in a blue world, or a green world, and then the condition of things would be different; but we can, in our laboratory, make our world red or green for the moment; but sometimes, indeed, when we do not seek to make this experiment, we find the world changed for us by the means which we employ for producing artificial lights, such as candles, gas, or the electric light; since in these, colours are not blended in the same way as in a sunbeam.

We thus come to the question of the radiation of light, and the way in which this light, whatever its quality, is reflected by natural objects; it is by this reflection that we see them. Everything that an artist paints which is white, is painted white by him for the simple reason that it reflects sunlight complete. It is perfectly clear that any reflecting surface can only reflect the light which it receives, although all surfaces do not reflect all of it—we have red walls and green trees; the direction of the light is not changed, except in the way of reflection, and you are already acquainted with the imperative law of optics

—that when light falls upon a body and is reflected, the angle of reflection is equal to the angle of incidence.

To us this drastic law is of the very highest interest. We can apply it to art in a great many ways, but I will only take two very simple ones. Oftentimes it is our fortune to be in the country by the side of a river, or at the seaside. In both cases we see things reflected in water, and at first sight it would seem that here the artist ought to find perfectly free scope; but the worst of it is that, though he has free scope, sometimes his picture becomes very unpleasant to people who are acquainted with the law I have stated. I find here some diagrams, prepared by the kindness of some of our friends, which will show you the intimate connection between art and science in this direction. In the pictures which you will see in the Royal Academy and the New Gallery, I fancy you will see some which, if you care to study them from this point of view, will be found not to agree with the law.

In the diagrams we have a surface of water and observers at the top and bottom of a cliff. We have on the other side of this surface of water a tree. Now, what anyone would do who disdains to “copy” Nature, and who paints without thinking, is this: he would paint what he saw on the bank, and then turn it upside down and paint it again. But you see that will not do, because the conditions are as you see them here. The higher spectator, No. 1, the angles of incidence and reflection being equal, although he can see the upper part of the tree and part of the trunk, will not be able to see it all completely reflected in the water. You see that the lower part of the tree cannot be seen in the reflection, because any light reflected by it first to the water and then to the eye is really cut off from the eye of the spectator by the bank; if you greatly vary your distance from the other side of the water, you will find the reflection as represented in the other diagram. Now, to anyone who has studied optics, if such a matter as this is represented wrongly in a picture, it becomes an intolerable nuisance, and when you go away you feel sorry that the artist did not do justice to what he wished to represent. A good example of truth to Nature in this respect is to be seen at the German Exhibition—No. 205—in one of the landscapes, which I saw last night; it is a beautiful instance of careful study, and is absolutely true in this respect. The artist has shown how a mountain side, with high lights upon it, reflected on the surface of a lake, appears very different in the reflection, in consequence of an intervening elevation near the edge of the water. When you have thought out the difference of the appearances on the lake and on the hillside, you will appreciate the truth and skill of the artist enormously.

Another serious fault arising from the neglect of this same law is to be found in very many pictures in which we get the reflection of the sun or moon in water.

Obviously, if the water is disturbed, the reflection upon the water must depend upon the direction of the disturbance. I need not say more than that to you. You will quite understand what I mean; but if you look at the pictures in the Royal Academy this year—Nos. 677, 1071, and 1155—you can see how very admirably this reflection can be rendered; and if you look at 165 and think the conditions out, you will wonder how the artist should trouble to paint something that is absolutely opposed to the physical law.

You know that, in those instances where you get a natural reflection, if the light source be beyond the object which reflects the light, the nearer it is in a line with it the more light will be reflected. You see that that rule relates to almost every landscape or seascape that is painted, for the reason that our air is filled with particles which reflect light. If it were not so, our atmosphere would be absolutely black.

It therefore follows that the light of the sky must increase in intensity as the sun or moon is approached—

that is to say, in a sun-setting or moon-setting, if you paint an unbroken sky, there must be an increase of intensity towards the light source. I am almost ashamed to make such a statement, because it is so obvious to you as students of science, but to the artist who is not a very strict observer, why should it strike him? The fact remains that it has not struck a great many artists. If you study the pictures Nos. 650, 989, 1144, in the Royal Academy, and No. 39 in the New Gallery, you will find there indications of a neglect of this law. Now the sky is far more luminous than it ought to be by the light indicated by the landscape. Again, the setting sun is not so bright as the clouds which it is supposed to illuminate, and in some cases there is absolutely no grazing reflection indicated, and, if anything, the sky is rather less luminous where the sun is than further away!

A good rule, and one which a student of physical science would be certain to act upon with considerable care, would be never to show anything as reflected which was not there.

An interesting example of this kind was exhibited in the Academy some years ago. It so happened that a French man of science wrote a book on physical phenomena, beautifully illustrated. Among the illustrations was a coloured copy of a photograph of a soap bubble. Now the laboratory in the Collège de France, in which the photograph was taken, was, like yours, very well lighted by many windows, and the soap bubble was blown in the middle of it. A translation of this book appeared in English, and the illustrations were reproduced.

An artist had a most excellent idea. He thought he would paint a picture of a garden, which he did admirably. The foreground looked bare, so he thought he would put children playing in it. It next struck him, apparently, that the children did not seem to be quite sufficiently occupied, so he painted one blowing soap bubbles. But, alas! less fortunate than you, the artist had no laboratory in which he could blow and study soap bubbles for himself; so what did he do? He copied the bubble which was riddled with windows, although there were no windows in the garden. He thought that the nature of bubbles was windowy.

Then, again, in the matter of reflection, it would not be right that I should fail to remind you that, besides things terrestrial, we have the moon, which rules the night, and rules the night because it reflects the sunlight to us. Now, in a little talk like this I must not take up much time with astronomy, but it is fortunate that books on astronomy can be got for 6d. or 1s. which will tell us, say, in half an hour, the chief points about the moon which we need consider in the present connection. The moon is lighted by the sun. The sun can only light one half at a time. If we are on the side of the moon which is lighted by the sun, we must see the complete lighted half which we call a full moon. If we see a full moon, we must have our back to the sun. When the position of the moon with reference to the earth is such that we can see half the lighted portion of the moon, we generally find that the part of the moon which is turned to the sun is lighted up.

But none of these things are so in art. Last year a picture in the Academy was absolutely disfigured by the dark part of the moon being turned to the sun. Surely it was not worth the artist's while to paint a moon if he did not know how to do it. But the moon has been treated, if possible, worse than that. Some years ago a friend who knew I was interested in astronomy had another friend who had painted a picture, and he wished me to look at it to see if the moon was right. I went and saw the picture, and had to say that the moon was wrong. It was perfectly clear that the picture was intended to represent the sun setting on the right, beyond the part of the landscape included in the picture, so that the moon rising on the left, and shown in the picture,

must be full. My friend said to me he knew this, and that as a matter of fact the artist had painted a full moon to start with, but he had altered it because it "destroyed the balance of his picture." That you see was where art came in. And then he added that the painter was not satisfied with the moon as it stood! I told my friend to say that I regretted that the full moon destroyed the balance of the picture, and that even a delicate crescent did not make things quite right, and I suggested that the effect of two or even three moons, of different sizes if needs be, should be tried. The artist said that this was nonsense; I replied that I did not consider it greater nonsense than the moon as he had represented it, and so the matter ended.

I am sure that the students of this College will know that such things as these are to be avoided, even if there were difficulties caused by the non-existence of a book on astronomy. No artist need paint a moon in a picture if he be too ignorant to paint it properly.

Everything that you paint in a picture, which you paint because it reflects light, should be painted its proper size in relation to the other objects. It seems, however, that the moment a body which reflects light does not happen to be on the surface of the earth, you may, in art, make it as large as you please. I do not think that the moon's distance from the earth gives us any right to treat it in this way.

An eminent American astronomer some years ago looked at the pictures in the New York galleries from this point of view. The moon subtends a certain angle. Everything else in a picture can be expressed in this way the moment you put a moon into it. This astronomer took the trouble to get out a statistical table of the heights of the different mountains and hills as drawn by American artists in pictures of places taken from other places (the distances being therefore known) with a moon thrown in. The maximum height was 105 miles, and the lowest 13!

Next, permit me to say a few words on another point, in order to show that the student of art will delight more and more in his work as he or she knows more and more of physical science. I now take refraction. You know that refraction can be divided into deviation and dispersion. The phenomena of deviation teach us that when a beam of light, whatever its colour, passes out of one medium into another its course is changed. An experiment, which is easily performed and which is more a home experiment than a laboratory one, is to put a coin into a basin and look over the edge in such a direction that the coin is just invisible: then fill it with water, the coin appears. Another experiment is to insert a straight body, such as a pencil, into this bowl of water: it appears to be broken; refraction, then, appears to make water shallower than it really is. If you look at 1094, you will find that this deviation has been made to act the wrong way.

It is rather a bad thing to attempt to paint a nymph partly in and partly out of *clear* water, because her body, if the picture be truly painted, would follow suit with the pencil.

Passing from deviation to dispersion we come to rain-bows. You have learned, and perhaps seen demonstrated by experiment, that we deal with a beam of white light coming from the sun and refracted at the front surface of a rain-drop. It is next reflected and again refracted down to the eye, so that the eye sees a bow, with all the spectrum colours due to the dispersion. If the light be strong enough, we get what is called a supplementary bow, and, in consequence of internal reflections, the two bows are brought together.

The point is that in this dispersion, brought about by the rain-drops, the effect is produced in a plane passing through the sun, your eye, and the rain-drop; your eye being in the centre, so that if you see a rainbow at all, you must have your back to the sun. The bow is always circular, and high or low according to the height of the

sun. Those are, of course, conclusions which a very restricted study of physical science will make perfectly clear: why you get the two reds together when two bows are visible; why the blue is inside, and the red outside the single bow, also follows from a demonstration which your teacher will give you, or which you can get from a book. The main point is that a rainbow is produced by a physical cause; so that, if you once grasp the idea of the cause of a rainbow, its whole anatomy will remain for ever with you.

It is quite impossible for you to see a rainbow in perspective, or projected on the sky as an ellipse. That will be quite clear, I think. Still, both these are recognized art-objects. I am sorry to say that in this year's Academy there is one case in which you will find that the fundamental condition of having your back to the sun has been neglected or forgotten by the artist. In No. 395 a most exquisite stump of rainbow is seen, most beautifully painted, and you naturally think, of course, that you have your back to the sun, but the artist has not been contented with painting the rainbow, he has painted cattle as well, and their shadows sweep across the picture. Another rainbow, 595, is excellently painted. The artist not only knows a great deal about rainbows, but wishes you to know that he knows, an umbrella being emphatically *en évidence*.

(To be continued.)

THE FARADAY CENTENARY.

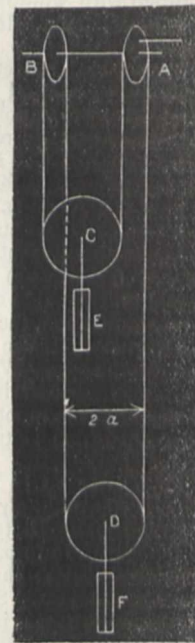
ON Wednesday, June 17, at the Royal Institution, Lord Rayleigh delivered a lecture in connection with the hundredth anniversary of Faraday's birth. The Prince of Wales presided.

Lord Rayleigh said that the man whose name and work they were celebrating was identified in a remarkable degree with the history of that Institution. If they could not take credit for his birth, in other respects they could hardly claim too much. During a connection of fifty-four years, Faraday found there his opportunity, and for a large part of the time his home. The simple story of his life must be known to most who heard him. Fired by contact with the genius of Davy, he volunteered his services in the laboratory of the Institution. Davy, struck with the enthusiasm of the youth, gave him the desired opportunity, and, as had been said, secured in Faraday not the least of his discoveries. The early promise was indeed amply fulfilled, and for a long period of years by his discoveries in chemistry and electricity Faraday maintained the renown of the Royal Institution and the honour of England in the eye of the civilized world. He should not attempt in the time at his disposal to trace in any detail the steps of that wonderful career. The task had already been performed by able hands. In their own Proceedings they had a vivid sketch from the pen of one whose absence that day was a matter of lively regret. Dr. Tyndall was a personal friend, had seen Faraday at work, had enjoyed opportunities of watching the action of his mind in face of a new idea. All that he could aim at was to recall, in a fragmentary manner, some of Faraday's great achievements, and if possible to estimate the position they held in contemporary science.

Whether they had regard to fundamental scientific import, or to practical results, the first place must undoubtedly be assigned to the great discovery of the induction of electrical currents. He proposed first to show the experiment in something like its original form, and then to pass on to some variations, with illustrations from the behaviour of a model, whose mechanical properties were analogous. He was afraid that these elementary experiments would tax the patience of many who heard him, but it was one of the difficulties of his task

that Faraday's discoveries were so fundamental as to have become familiar to all serious students of physics.

The first experiment required them to establish in one coil of copper wire an electric current by completing the communication with a suitable battery; that was called the primary circuit, and Faraday's discovery was this: That at the moment of the starting or stopping of the primary current, then, in a neighbouring circuit, in the ordinary sense of the words, completely detached, there was a tendency to induce a current. He had said that those two circuits were perfectly distinct, and they were distinct in the sense that there was no conducting communication between them, but, of course, the importance of the experiment resided in this—that it proved that in some sense the circuits were not distinct; that an electric current circulating in one does produce an effect in the other, which is propagated across a perfectly blank space occupied by air, and which might equally well have been occupied by vacuum. It might appear that that was a very simple and easy experiment, and of course it was so in a modern laboratory, but it was otherwise at the time when Faraday first made it. With all his skill, Faraday did not light upon truth without delay and difficulty. One of Faraday's biographers thus wrote:—"In December 1824, he had attempted to obtain an electric current by means of a magnet, and on three occasions he had made elaborate and unsuccessful attempts to produce a current in one wire by means of a current in another wire, or by a magnet. He still persevered, and on August 29, 1831—that is to say, nearly seven years after his first attempts—he obtained the first evidence that an electric current induced another in a different circuit. On September 23rd, he writes to a friend, R. Phillips: I am busy just now again with electro-magnetism, and think I have got hold of a good thing, but cannot say; it may be a weed instead of a fish that, after all my labour, I at last haul up." We now know that it was a very big fish indeed. Lord Rayleigh proceeded to say that he now proposed to illustrate the mechanics of



the question of the induced current by means of a model (see figure), the first idea of which was due to Maxwell. The one actually employed was a combination known as Huygens's gear, invented by him in connection with the winding of clocks. Two similar pulleys, A, B, turn upon a piece of round steel fixed horizontally. Over these is

hung an endless chord, and the two bights carry similar pendant pulleys, C, D, from which again hang weights, E, F. The weight of the cord being negligible, the system is devoid of potential energy; that is, it will balance, whatever may be the vertical distance between C and D. Since either pulley, A, B, may turn independently of the other, the system is capable of two independent motions. If A, B turn in the same direction and with the same velocity one of the pendant pulleys, C, D, rises, and the other falls. If, on the other hand, the motions of A, B are equal and opposite, the axes of the pendant pulleys and the attached weights remain at rest. In the electrical analogue the rotatory velocity of A corresponds to a current in a primary circuit, that of B to a current in a secondary. If, when all is at rest, the rotation of A be suddenly started, by force applied at the handle or otherwise, the inertia of the masses E, F opposes their sudden movement, and the consequence is that the pulley B turns *backwards*, *i. e.* in the opposite direction to the rotation imposed upon A. This is the current induced in a secondary circuit when an electromotive force begins to act in the primary. In like manner, if A, having been for some time in uniform movement, suddenly stops, B enters into motion in the direction of the former movement of A. This is the secondary current on the break of the current in the primary circuit. It might perhaps be supposed by some that the model was a kind of trick. Nothing could be further from the truth. The analogy of the two things was absolutely essential. So far was this the case that precisely the same argument and precisely the same mathematical equations proved that the model and the electric currents behaved in the way in which they had seen them behave in the experiment. That might be considered to be a considerable triumph of the modern dynamical method of including under the same head phenomena the details of which might be so different as in this case. If they had a current which alternately stopped and started, and so on, for any length of time, they, as it were, produced in a permanent manner some of the phenomena of electrical induction. The particular apparatus by which he proposed to illustrate those effects of the alternating current was devised by a skilful American electrician, Prof. Elihu Thomson, and he had no doubt it would be new to many. The alternating current was led into the electro-magnet by a suitable lead; if another electric circuit, to be called the secondary circuit, was held in the neighbourhood of the first, currents would be induced and might be made manifest by suitable means. Such a secondary circuit he held in his hand, and it was connected with a small electric glow lamp. If a current of sufficient intensity were induced in that secondary circuit it would pass through the lamp, which would be rendered incandescent. [Illustrating.] It was perfectly clear there was no conjuring there; the incandescent lamp brightened up. One of the first questions which presented itself was, what would be the effect of putting something between? Experimenting with a glass plate, he showed there was no effect, but when they tried a copper plate the lamp went completely out, showing that the copper plate was an absolute screen to the effect, whatever it might be. Experiments of that kind, of course in a much less developed and striking form, were made by Faraday himself, and must be reckoned amongst some of his greatest discoveries.

Before going further, he might remark on what strong evidence they got in that way of the fact that the propagation of the electric energy which, having its source in the dynamo downstairs, eventually illuminated that little lamp, was not merely along the wires, but was capable of bridging over and passing across a space free from all conducting material, and which might be air, glass, or, equally well, vacuum. Another kindred effect of a striking nature, devised by Prof. Elihu Thomson, consisted in

the repulsive action which occurred between the primary current circulating around a magnet and the current induced in a single hoop of aluminium wire. Illustrating this by experiment, he showed that the repulsion was so strong as to throw the hoop up a considerable height. Those effects were commonly described as dependent upon the mutual induction between two distinct circuits, one being that primarily excited by a battery or other source of electricity, while the other occurred in a detached circuit. Many surprising effects, however, depended on the reactions which took place at different parts of the same circuit. One of these he illustrated by the decomposition of water under the influence of a single Daniell cell with the aid of self-induction.

About the time that the experiments of which he had been speaking were made, Faraday evidently felt uneasiness as to the soundness of the views about electricity held by his contemporaries, and to some extent shared by himself, and he made elaborate experiments to remove all doubt from his mind. He re-proved the complete identity of the electricity of lightning and of the electricity of the voltaic cell. He was evidently in terror of being misled by words which might convey a meaning beyond that which facts justified. Much use was made of the term "poles" of the galvanic battery. Faraday was afraid of the meaning which might be attached to the word "pole," and he introduced a word since generally substituted, "electrode," which meant nothing more than the way or path by which the electricity was led in. "Electric fluid" was a term which Faraday considered dangerous, as meaning more than they really knew about the nature of electricity, and as was remarked by Maxwell, Faraday succeeded in banishing the term "electric fluid" to the region of newspaper paragraphs.

Diamagnetism was a subject upon which Faraday worked, but it would take him too long to go into that subject, though he must say a word or two. Faraday found that whereas a ball of iron or nickel or cobalt, when placed near a magnet or combination of magnets, would be attracted to the place where the magnetic force was the greatest, the contrary occurred if for the iron was substituted a corresponding mass of bismuth or of many other substances. The experiments in diamagnetism were of a microscopic character, but he would like to illustrate one position of Faraday's, developed years afterwards by Sir Wm. Thomson, and demonstrated by him in many beautiful experiments, only one of which he now proposed to bring before them. Supposing they had two magnetic poles, a north pole and a south pole, with an iron ball between them, free to move along a horizontal line perpendicular to that joining the poles, then, according to the rule he had stated, the iron ball would seek an intermediate position, the place at which the magnetic force was the greatest. Consequently, if the iron ball be given such a position, they would find it tended with considerable force to a central position of equilibrium; but if, instead of using opposite poles, they used, *e.g.*, two north poles, they would find that the iron ball did not tend to the central position, because that was not the position in which the magnetic force was the greatest. At that position there was no magnetic force, for the one pole completely neutralized the action of the other. The greatest force would be a little way out, and that, according to Faraday's observations, systematized and expressed in the form of mathematical law by Sir Wm. Thomson, was where the ball would go. [This was illustrated by experiment.]

The next discovery of Faraday to which he proposed to call attention was one of immense significance from a scientific point of view, the consequences of which were not even yet fully understood or developed. He referred to the magnetization of a ray of light, or what was called

in more usual parlance the rotation of the plane of polarization under the action of magnetic force. It would be hopeless to attempt to explain all the preliminaries of the experiment to those who had not given some attention to those subjects before, and he could only attempt it in general terms. It would be known to most of them that the vibrations which constituted light were executed in a direction perpendicular to that of the ray of light. By experiment he showed that the polarization which was suitable to pass the first obstacle was not suitable to pass the second, but if by means of any mechanism they were able, after the light had passed the first obstacle, to turn round the vibration, they would then give it an opportunity of passing the second obstacle. That was what was involved in Faraday's discovery. [Experiment.] As he had said, the full significance of the experiment was not yet realized. A large step towards realizing it, however, was contained in the observation of Sir William Thomson, that the rotation of the plane of polarization proved that something in the nature of rotation must be going on within the medium when subjected to the magnetizing force, but the precise nature of the rotation was a matter for further speculation, and perhaps might not be known for some time to come.

When first considering what to bring before them he thought, perhaps, he might include some of Faraday's acoustical experiments, which were of great interest, though they did not attract so much attention as his fundamental electrical discoveries. He would only allude to one point which, as far as he knew, had never been noticed, but which Faraday recorded in his acoustical papers. "If during a strong steady wind, a smooth flat sandy shore, with enough water on it, either from the receding tide or from the shingle above, to cover it thoroughly, but not to form waves, be observed in a place where the wind is not broken by pits or stones, stationary undulations will be seen over the whole of the wet surface. . . . These are not waves of the ordinary kind, they are (and this is the remarkable point) accurately parallel to the course of the wind." When he first read that statement, many years ago, he was a little doubtful as to whether to accept the apparent meaning of Faraday's words. He knew of no suggestion of an explanation of the possibility of waves of that kind being generated under the action of the wind, and it was, therefore, with some curiosity that two or three years ago, at a French watering-place, he went out at low tide, on a suitable day when there was a good breeze blowing, to see if he could observe anything of the waves described by Faraday. For some time he failed absolutely to observe the phenomenon, but after a while he was perfectly well able to recognize it. He mentioned that as an example of Faraday's extraordinary powers of observation, and even now he doubted whether anybody but himself and Faraday had ever seen that phenomenon.

Many matters of minor theoretic interest were dealt with by Faraday, and reprinted by him in his collected works. He was reminded of one the other day by a lamentable accident which occurred owing to the breaking of a paraffin lamp. Faraday called attention to the fact, though he did not suppose he was the first to notice it, that, by a preliminary preparation of the lungs by a number of deep inspirations and expirations, it was possible so to aerate the blood as to allow of holding the breath for a much longer period than without such a preparation would be possible. He remembered some years ago trying the experiment, and running up from the drawing-room to the nursery of a large house without drawing any breath. That was obviously of great practical importance, as Faraday pointed out, in the case of danger from suffocation by fire, and he thought that possibly the accident to which he alluded might have been spared had the knowledge of the fact to which Faraday drew attention been more generally diffused.

The question had often been discussed as to what would have been the effect upon Faraday's career of discovery had he been subjected in early life to mathematical training. The first thing that occurred to him about that, after reading Faraday's works, was that one would not wish him to be anything different from what he was. If the question must be discussed, he supposed they would have to admit that he would have been saved much wasted labour, and would have been better *en rapport* with his scientific contemporaries if he had had elementary mathematical instruction. But mathematical training and mathematical capacity were two different things, and it did not at all follow that Faraday had not a mathematical mind. Indeed, some of the highest authorities (and there could be no higher authority on the subject than Maxwell) had held that his mind was essentially mathematical in its qualities, although they must admit it was not developed in a mathematical direction. With these words of Maxwell he would conclude: "The way in which Faraday made use of his idea of lines of force in co-ordinating the phenomena of electric induction shows him to have been a mathematician of high order, and one from whom the mathematicians of the future may derive valuable and fertile methods."

THE ROYAL NAVAL EXHIBITION.

THE Naval Exhibition, now being held at Chelsea, is distinctly a popular show. The management—recognizing that the first duty of an Exhibition is not to show a pecuniary deficit—has wisely decided to follow the lead given by Sir Philip Cunliffe Owen, and has devoted the chief of its energies to fireworks, waxworks, peep-shows, pictures, shooting-galleries, mimic sham fights, and musical entertainments of a kind known to sailors as "sing-songs." The end justifies the means. Not only does the Committee of distinguished Admirals labour to supply Londoners with a cheap and innocent means of enjoyment, but the final result will be the establishment of a substantial fund to endow a most deserving charity. Fortunately there are features which possess a more serious interest; and though there may be nothing especially new in the Exhibition, the man of science who has not been brought much in contact with naval matters may find there a good deal that is worth consideration.

The Exhibition appears to be divided into about half-a-dozen sections, each under the direction of a committee. Of these the "Entertainments" and "Refreshments" Committees are of course the chief; but the Models Committee appears to be the one which has made the most serious effort to present a distinctly naval subject in logical sequence. In the Seppings Gallery there is a collection of models of warships illustrating the progress of naval architecture, from the *Great Harry* down to the very latest design of armour-clad battleship. The model of the *Great Harry* is of very doubtful authenticity, and is of modern construction, having been made by the aid of such pictures of the great sixteenth-century ship as exist. No historical collection of British warships would, however, be even approximately complete without a representation of this vessel. Charnock, our great authority on the subject, has styled her "the parent of the British Navy"; and if it be true, as supposed, that she was the first warship to sail on a wind, the claim is most amply justified. In fact, naval architecture as a science was not founded until it was discovered that ships could be, otherwise than by the aid of oars, taken to the quarter from which the wind was blowing. It must have seemed a great feat in those days—little less than necromancy. Fortunately for the timid intellects of our ancestors, the revelation broke upon them gently, for the rounded hulls, high topsides, and curiously rigged craft could not have sailed more than a point or two to wind-

ward. Still, it was the *Great Harry*, or one of her contemporaries, by means of which this new feature in seamanship was inaugurated; a feature by which the great middle period in the world's history of naval warfare was created, and which enabled the sailors of those times to make a distinct advance upon the lessons taught them by their instructors in the art of shipcraft, the Phœnicians, Romans, and Scandinavians. It would have been well if we had improved on our predecessors in other nautical matters as well; and we then should not have had, even in the present century, our shipwrights attaching lead sheathing to ships' bottoms with iron nails. The Romans used copper fastenings when they lead-covered the under-water part of their vessels.

There are but three models of seventeenth-century ships in the Exhibition, but one of these is a vessel that forcibly illustrates, by contrast, the mutability of the present age. The *Royal William* was designed by the first great naval architect, Phineas Pett—whose name might almost more appropriately have been given to the Models Gallery than that of Seppings—and was built at Chatham in 1670. She was originally a three-decker, carrying one hundred guns, but in 1757 she was cut down to a ship of 84 guns, and was finally broken up in 1813—a fact duly recorded by the present Director of Naval Construction, Mr. W. H. White, in his delightful lecture on "Modern War Ships," delivered a few years ago at the Mansion House. The *Royal William* must not, however, be taken as an example of the endurance of ancient materials so much as of the slow changes in design which characterized the proceedings of our ancestors. The original material part of the *Royal William* only lasted twenty-two years, for she was rebuilt, we are told, in 1692, and again in 1719; so that in this respect she compares unfavourably with so modern a vessel as our first ironclad, the *Warrior*, which has only recently been taken out of the Navy after a service career of not far from 30 years. Even now the *Warrior* has not been removed from the Navy list because she has become worn out, but simply because she has become obsolete. If we could reach finality in design—if the inventive brain would stagnate—there is no reason why the modern iron-built warship should not outlast its wooden predecessor by almost as great an extent as it exceeds it in power of destruction. It is true the natural life of the old ships was a long one. The *Victory* was forty years old when she was engaged in the battle of Trafalgar, and had seen much active service, having been launched at Chatham in 1765; but then she had been laid by as worn out in 1801, and it was only after extensive repairs that she was made fit for sea. A year or two ago, it will be remembered, she was found to be so rotten that she would have sunk at her moorings had she not been taken into dock and in part rebuilt. On the other hand, there is no reason why an iron ship should not last, provided she were properly painted and kept up, perhaps until the era when warships will have become relics of a barbarous past. The expression "properly painted" must be here taken in its literal sense; and with regard to steel ships due steps must be followed to remove mill-scale, a precaution which has not always been taken of late, as quite recent mishaps have testified.

Passing from hulls to motive power, we find the same governing principles as to durability of material and impermanence of design more strongly emphasized in the practice of to-day compared with that of the naval era which closed with the introduction of steam and iron hulls. With comparatively small variations in detail the rig of war ships has remained unchanged from the days of Pett down to those within the memory of men still living. The *Henri Grace à Dieu* shows a distinctly mediæval rig—although her fighting-tops are ridiculously like those of our very latest armour-clads—but it would take almost a sailor's eye to point out the differences in sail plan between

Vandevelde's beautiful painting of the *Sovereign of the Seas*, "built in 1637," and the ships which appear on the canvases of Stanfield, Turner, and Cooke. So much for permanence of design with masts and sails; with the succeeding mode of propulsion, engines and boilers, we find as striking a result in the opposite direction. Steam machinery was first introduced into the Royal Navy in small gun-boats, and later in the paddle-wheel frigates, but it was not until the screw was proved to be the more effective instrument that even the most sanguine engineers could hope that engines and boilers would successfully rival masts and sails as a means of propulsion. We pass over, therefore, the unimportant era of paddle-wheels, but even taking screw engines alone we find that during the last forty years far greater changes have taken place in the design of steam machinery than characterized the arrangement of masts and sails during the two hundred years elapsing between the time the *Sovereign of the Seas* was built and the practical introduction of steam into the Navy; indeed we might, without any great fear of contradiction, go further and say that to the eye of the engineer there is no greater affinity between the screw engines of forty years ago and those of the present day, than existed between the rigging of the ships of the Norse sea-kings and those of almost our own day, putting on one side only the element of size. The collection of engine models in the Exhibition is far from complete, and is not to be compared with that of ship models. There is a good reason for this, as engineers work to drawings, and models are seldom made excepting as records; whilst their cost is so great as to render them available only for very rich firms. The collection of models shown by Messrs. Maudslay, Sons, and Field constitute the greater part of the historical collection in the Exhibition. Here may be seen representations of the first types of steam-engine introduced into the Navy; and we think a comparison of the early engines in this collection with, say, the magnificent model of the *Sardegna's* engines, shown by Messrs. Hawthorn, Leslie, and Co., will bear out the remarks we have made. What path the progress of marine engineering will follow in future it is difficult to forecast. The inventions of to-day always seem to have reached finality, but it is difficult to imagine that any fundamental change can be effected so long as we retain the use of steam as a vehicle for the conversion of heat into work. It may be that a little engine shown in the Exhibition—Priestman's oil engine—may contain the germ of a principle upon which marine engines may be designed in future, and that before we have got far into the twentieth century the marine boiler, with all its costliness and complication, may have become as much a relic of the past as the pole masts and uncouth sails of the *Great Harry*. Before that time arrives, however, the four-stroke cycle will have to be superseded.

It is, however, the steam boiler, rather than the engine, which has governed the design of ship machinery. Forty-to forty-five years ago, steam pressures were not generally higher than 5 to 8 pounds per square inch. With the introduction of tubes in place of flues, which took place between 1840 and 1850, the working pressure rose to 15 pounds per square inch. The square box boiler was in use, and with that type the working pressure was limited to about 30 pounds per square inch, or not much beyond, unless the staying of the flat surfaces was carried to an undesirable extent. With such a limit of pressure, the simple expansion engine was, properly, the usual type, but when the cylindrical marine boiler was introduced, the average steam pressure quickly rose to 60 pounds to the square inch, and the compound engine naturally followed. The surface condenser formed a necessary part of this step in advance, for, with the higher temperature due to the increased steam pressure, it was impossible to pass large quantities of salt water through the boilers without rapidly scaling them up. For some time the

difficulty in generating higher pressure steam caused stagnation in marine engineering practice; until the substitution of steel for iron in boiler making, the advent of new types of furnaces, and improvements in the machinery used in boiler construction have enabled pressures as high as from 150 pounds to even 200 pounds to the square inch to be carried. The result has been that, for the two-cylinder compound engine, there have been substituted two types of engine, known respectively as the triple expansion engine and the quadruple expansion engine. The names are misleading, as even the ordinary compound engine expands its steam more than three or four times.

The growth of the science of marine engine design, which we have so briefly sketched out, may appear, to those who are not engineers, but little more than a record of increasing steam pressures. Undoubtedly a higher steam pressure has been the fundamental reason for these advances, but the carrying out of these successive changes in pressure has necessitated an entire reconstruction of marine engine practice; so that an engine working at 15 pounds pressure can hardly be said to belong to the same category as one working at 150 to 200 pounds pressure. Tooth-wheel gearing, which was first used with screw propellers, has long ago disappeared, side levers and trunks are no longer introduced, and the surface condenser has become a necessity. In the old days, with jet condensers, the boilers were fed entirely with salt water, now in the best marine practice the condensed steam is all returned to the boiler, excepting that which is unavoidably lost, and this quantity is made up by special distillers and condensers, the manufacture of which has introduced a new branch of marine engineering, as may be judged by several exhibits by different firms in the Exhibition. The practice of circulation of refrigerating water through the surface condenser by means of separate centrifugal pumping engines has also introduced a distinctive type of auxiliary marine engine, upon which several important firms have been chiefly employed. Indeed, the increase in auxiliary machinery has been as marked a feature in the recent progress of marine engineering as have been the changes in the main engines themselves. A battleship of the first class will carry between seventy and eighty separate engines, in addition to those used for driving the propellers. These include electric light engines, hydraulic machinery in connection with the working of heavy guns, steering engines, &c. As an instance of what is gained by the use of auxiliary machinery, an instance given by Mr. White may be quoted. On one occasion it took 78 men $1\frac{1}{2}$ minutes to put the helm of the *Minotaur* hard over. Steam gear was subsequently fitted, by the aid of which two men were able to do the same thing in 16 seconds.

We do not propose to give a list of the various objects exhibited, to which we have referred in penning these remarks. The official catalogue performs that function far more completely than we could hope to do. The collection at Chelsea is well selected and fairly complete, and there will be found there material for object-lessons in all we have advanced in this brief sketch. We may, however, with advantage, add a few figures as to money cost, which cannot fail to be of interest, and for which we are indebted to the Director of Naval Construction. The cost of a 100-gun line-of-battle ship at the beginning of the century was about £65,000 to £70,000, armament and stores being excluded. The corresponding outlay on the 110-gun sailing three-deckers of 1840 was about £110,000; and that of the 121-gun screw three-deckers of 1859 about £230,000, machinery included. The *Warrior*, completed in 1861, cost over £575,000; and the *Minotaur* class about £480,000. With the increase in size of the *Dreadnought*, and the introduction of hydraulic mechanism, came an increase of cost to £620,000; while the *Inflexible* cost no less than £810,000."

The *Nile* and *Trafalgar*, complete with armament, would represent little less than a million sterling each. The cost of the armour-plating, propelling machinery, and hydraulic gun mountings alone, would have paid for five first-rates of Nelson's time. The sum paid for the armour alone on one of our latest battleships, such as the *Royal Sovereign*, would pay for the Natural History Museum at South Kensington; whilst even a first-class torpedo-boat costs as much to build and equip as a 40-gun frigate of Nelson's time.

A GEOLOGICAL EXCURSION IN AMERICA.

I BEG to call to your attention the following short account of a geological excursion planned for the benefit of foreign geologists who may attend the coming meeting of the International Geological Congress in this city in August next. It will afford an exceptionally favourable opportunity for European geologists to become personally familiar with the most important geological phenomena of the United States.

I venture, therefore, in their interest, to request that you publish some notice of it in your widely circulated periodical, with a request that those who desire to take part in it will kindly advise me as early as possible, in order that arrangements may be thoroughly perfected beforehand. A single train will carry 75 to 100 persons comfortably. If more join, the party will be arranged in two trains. Arrangements will have to be made beforehand at the various stopping places along the road for the reception of the party, and you can therefore readily understand the importance of knowing as early as possible how many are to be accommodated.

S. F. EMMONS, Secretary.

Washington, D.C., May 30.

For the close of the fifth session of the International Congress of Geologists, which is to be held at Washington, D.C., from August 26 to September 2, a grand geological excursion has been organized, which presents unusual attractions and facilities for the European geologists who attend the Congress, and who wish to see some of the geological wonders which have become familiar to them through the memoirs of American geologists. The excursionists will start from Washington, on September 3, on a special train of Pullman vestibuled cars, which will constitute a moving hotel, being provided with sleeping and toilet accommodations for both ladies and gentlemen, restaurant cars, smoking, reading, and bath rooms, and barber's shop, and so arranged that travellers can pass freely at all times from car to car through covered passages. It will accompany the party wherever the rails are laid in the regions visited, the hours being arranged so that all the most interesting portions of the route will be passed over in the daytime, and stops may be made wherever any object of special interest to the travellers presents itself. American geologists who have made special studies of the different regions visited will accompany the train, and explain their geological structure upon the ground. The main route laid out is over 6000 miles (nearly 10,000 kilometres) in length, and extends over 38° of longitude and 12° of latitude. It is planned to occupy 25 days, and the cost per person will be 265 dollars (1325 francs), which will cover all necessary expenses, of whatever kind, during the trip.

The following are the principal objects of geological interest which will be seen by those who make the excursion:—

Going westward, the Appalachian Mountains are first crossed, and an opportunity will be had to see the closely appressed Palæozoic rocks which constitute their typical structure. The prairie region of Indiana and Illinois, at the southern end of Lake Michigan, its ancient outlet

into the Mississippi River, will be seen on the second day, and the Kettle moraines of the ancient Glacial sheet will be visited under the guidance of Prof. Chamberlin. On the third day the twin cities of Minneapolis and St. Paul, centres of the great wheat-growing region of the north-west, will be visited, and glacialists will have an opportunity to see one of the time gauges of the Glacial period, at the Falls of St. Anthony, on the Mississippi River.

During the fourth day the Great Plains of Dakota will be crossed, and toward its close the characteristic Badland topography of the Upper Missouri region will be seen. On the morning of the fifth day the travellers will leave the train at the entrance to the Yellowstone Park, and during the following week will be transported by stages through the Park region, stopping at rustic hotels established near points of special interest. The various geyser basins, the hot lakes and mud volcanoes, the obsidian cliffs, the falls and cañon of the Yellowstone River, the Yellowstone Lake, and other objects of interest, will be successively visited under the guidance of Messrs. Arnold Hague and Jos. P. Iddings.

On the twelfth day the railroad journey will be resumed, and, after crossing the crest of the Rocky Mountains in Montana, a stop of several hours will be made at the famous mining town of Butte, whose mines produced, during 1890, over 26 million dollars worth of copper, silver, and gold.

The morning of the thirteenth day will find the travellers on the edge of the great lava plains of the Snake River. Those especially interested in volcanic phenomena will have an opportunity here of making a side trip across these plains to Shoshone Falls, where the Snake river makes a single leap of over 200 feet, and cuts a narrow gorge 600 feet deep in the andesitic and basaltic lavas. The main party meanwhile will proceed southward into Utah, viewing the desert mountain ranges, the shore-lines of ancient Lake Bonneville, and skirting the shores of its present relic, the Great Salt Lake, will reach Salt Lake City, the Mormon capital, in the afternoon. A halt of three days will be made in Salt Lake City, which will give the travellers an opportunity of seeing the Mormons, the desert scenery around Salt Lake (with bath in the lake), and the magnificent Wahsatch Mountains. The Pleistocene phenomena will be explained by Mr. G. K. Gilbert, and the mountain structure and mining geology by Mr. S. F. Emmons.

On the sixteenth day the railroad journey will be continued across the Wahsatch Mountains into the plateau region of the Colorado River, crossing that stream in the afternoon, and obtaining views of great monoclinal scarps, and groups of laccolitic mountains in the distance.

On the seventeenth day the Rocky Mountain region of Colorado will be entered, through its finest cañon gorges, affording wonderful geological sections. Halts of a few hours each will be made at Glenwood Springs and at the famous mining town of Leadville, which has produced over 150 million dollars worth of silver and lead.

On the eighteenth day the train will descend the great mountain valley of the Arkansas River, between mountain peaks over 14,000 feet high, and through cañon gorges 3000 feet deep, debouching upon the plains through the Royal Gorge at Cañon City, where a remarkable geological section in the "Hogback" ridges will be visited. A short stop will be made at Pueblo, a great centre of smelting works; and Manitou Springs, in a sheltered nook under Pike's Peak, will be reached in the evening.

The nineteenth day will be spent at Manitou Springs, the vicinity of which abounds in objects of geological and mineralogical interest, and those who wish may make the ascent of Pike's Peak (14,200 feet) by rail.

The twentieth day will be spent at Denver, the capital of Colorado, a beautiful city of 130,000 inhabitants,

having a view of the whole eastern front of the Rocky Mountains. For those who desire it, a further excursion of ten days or more will be organized under the guidance of J. W. Powell and C. E. Dutton, to the Great Cañons of the Colorado River in Arizona, which they have so fully described in their writings. More detailed visits to the mining districts of Colorado will be directed by S. F. Emmons for those who wish to remain over for that purpose. Those who remain over will receive tickets securing them passage to New York by regular trains when they are ready to start.

The special train will leave Denver on the evening of September 21, crossing the Great Plains of Kansas and Nebraska and the Mississippi Valley, and reaching Chicago on the evening of the 23rd. A day will be given to Chicago, and thence the train will skirt the Great Lakes, Michigan, Huron, and Erie, crossing a portion of Canada, and reaching Niagara Falls on the morning of September 25. Leaving there in the evening, the travellers will descend the beautiful valley of the Hudson River early the following morning, and reach New York before noon of September 26.

NOTES.

THE Delegates of the University Press have informed Prof. Sylvester that they will be prepared to bear the expense of publishing in quarto a complete edition of his mathematical works. We understand that a memorial recommending this course was addressed to the Delegates of the Press, numerous signed by leading mathematicians of the two English Universities, and by eminent members of the French Academy of Sciences.

GEOLOGISTS on this side of the Atlantic will learn with deep regret that Captain Dutton, whose admirable memoirs in the Reports and Monographs of the U. S. Geological Survey are so widely known and valued, has been ordered to take up military duty in Texas—a wide pastoral region where his genius as a geological explorer will find no scope for exercise. As a member of the Corps of Engineers, he has of course always been liable to be taken away to mere routine service of this kind, for which any ordinary officer of his grade would be sufficient. But the authorities have hitherto appreciated his remarkable powers, and have allowed them free exercise, much to their own credit and greatly for the benefit of science. Whether a new martinet has resolved to apply the rigid rules of the service we do not know. But surely there ought to be public spirit enough in the United States to put such pressure on the Engineer Department as will make it reconsider its arrangements. It has only one Captain Dutton, and should be proud of him and make the most of him.

THE Council of the Royal Meteorological Society has decided to arrange for a general dinner, open to all Fellows and their friends, to be held in commemoration of the entrance of the Society on its new premises. The dinner will take place at the Holborn Restaurant on Tuesday, July 7, at 6.30 p.m.

THE Committee appointed by the Hebdomadal Council, Oxford, to consider in what way the University could assist in the establishment of agricultural education, with a special view to the needs of the County Councils, have now submitted their report. By agricultural education the Committee understand instruction in the sciences, or the branches of science, specially applicable to agriculture, employing the latter term with the larger meaning which must have been present to the mind of Dr. Sibthorp when he designated the professorship founded by him the professorship of "Rural Economy." Used in this sense agriculture becomes not merely the science of the cultivation of the soil, but includes the knowledge of its constitution and properties, of its vegetable products, and of the structure, habits, and uses of the domestic animals that are

reared upon it; so that the student has evidently much to gain by a knowledge of such subjects as botany, chemistry, animal physiology, and geology. Taking into account the requirements of the County Councils, the Committee think that the efforts of the University should in the first place be directed to the provision of an adequate supply of persons qualified to be lecturers or teachers; and those members who are most familiar with the wants of the counties lay stress upon the importance of University teachers possessing credentials of practical acquaintance with the details of farming and farm-life, which has hitherto been only accidentally—if at all—acquired by such teachers. Other classes of persons whose circumstances the Committee think deserving of consideration are young men who go to Oxford intending to take an ordinary degree, and then, either as landowners or the agents of landowners, to devote themselves to the pursuit and improvement of agriculture; and young men who might go to Oxford with a view to attending such courses of instruction as would be useful to them in agriculture, but without the intention of taking a degree. Dealing with the means already at the command of the University for providing agricultural education, the Committee point out that the professors to whose services resort would most naturally be had are the following: the Sibthorpe Professor of Rural Economy, the Sherardian Professor of Botany, the Waynflete Professor of Chemistry, the Waynflete Professor of Physiology, and the Professor of Experimental Philosophy (Physics). In addition to these University Professors, there are the Lee's Readers in Chemistry and Physics at Christ Church, and the Millard Lecturer in Physics at Trinity College, whose courses would probably be open to agricultural students. The Committee sketch the proper course of study for each class of students, and express the opinion that for the organization and supervision of the studies pertaining to agricultural education some further provision is needed than at present exists. In the Sibthorpe Professorship of Rural Economy, which is now vacant, they recognize a foundation capable of being rendered the centre of agricultural education within the University; and they strongly recommend that the duties and emoluments of the chair should be revised.

THE annual dinner of the Royal Horticultural Society was held on Tuesday evening at the Hôtel Métropole. The chair was taken by Sir Trevor Lawrence, the President. The toast of the evening, "The Royal Horticultural Society," was proposed by Sir James Paget, who spoke of the work in which the Society was engaged as one that ministered to the happiness and welfare of the whole nation. The President responded. The Society is now in a most prosperous condition, and is to be congratulated on the progress it has made under Sir Trevor Lawrence's leadership.

WE print elsewhere a report of the lecture delivered by Lord Rayleigh at the Royal Institution last week in connection with the Faraday Centenary. In commemoration of this anniversary the Royal Institution elected as honorary members a number of foreign men of science, several of whom came to London to be presented with the diploma of membership by the Prince of Wales. As the distinction between the Royal Institution and the Royal Society is not always so well understood in foreign countries as it is in England, the Royal Institution can hardly, perhaps, be congratulated on this "new departure." The following is the list of those on whom the honour was conferred:—Edmond Becquerel, Marcellin Berthelot, Alfred Cornu, E. Mascart, Louis Pasteur, Paris; R. W. Bunsen, Heidelberg; H. L. F. von Helmholtz, A. W. von Hofmann, Rudolph Virchow, Berlin; J. P. Cooke, Cambridge, U.S.; J. Dwight Dana, J. Willard Gibbs, Newhaven, U.S.; Simon Newcomb, Washington, U.S.; Stanislas Cannizzaro, Pietro Tacchini, Rome; Julius Thomsen, Copenhagen; T. R. Thalen, Upsala; Demetri Mendeleef, St. Petersburg; J. C. G. de Marignac,

Geneva; J. D. van der Waals, Amsterdam; J. Servais Stas, Brussels.

A COMMISSION has been appointed for the reorganization of the Paris Museum of Natural History, and held its first meeting last week under the presidency of the Minister of Public Instruction. The members are MM. Berthelot, Bardoux, Burdeau, Charles Dupuy, Darboux, Frémy, Chauveau, Milne-Edwards, and Liard.

A *conversazione* will be given by the President of the Institution of Electrical Engineers and Mrs. Crookes in the galleries of the Royal Institute of Painters in Water Colours on Monday evening, July 6.

ON Monday evening, in the House of Commons, Sir H. Roscoe asked the President of the Board of Trade whether he had decided to grant the application of the Committee of the National Institute of Preventive Medicine to become incorporated under the Companies Act, with the omission of the word "limited" in view of the amended proposals which had been placed before him. Sir M. Hicks-Beach replied as follows:—"The amendment of the proposed memorandum of association referred to by the hon. member (by which it is made clear that the grant of the licence now asked for would not in any way imply approval by the Board of Trade of experiments upon living animals, or of any application to the Home Secretary for a licence for that purpose) is, no doubt, an important change in the proposals of the Institute, and will probably meet the objection stated to the deputation which lately waited upon me. There are, however, one or two other points requiring consideration, but I hope shortly to be able to arrive at a decision on the subject."

SIR PRESCOTT GARDINER HEWETT, F.R.S., died on Friday night last at his residence, Chestnut Lodge, Horsham, Sussex. He was born in 1812, and in 1836 was admitted a member of the Royal College of Surgeons, of which he was made President in 1876, in succession to Sir James Paget.

WITH the approval of the President, the Prince of Wales, the Council of the Society of Arts have awarded the Albert Medal to Sir Frederick Abel, K.C.B., "in recognition of the manner in which he has promoted several important classes of the arts and manufactures, by the application of chemical science, and especially by his researches in the manufacture of iron and of steel; and also in acknowledgment of the great services he has rendered to the State in the provision of improved war material, and as chemist to the War Department."

THE Report of the Savilian Professor of Astronomy has been presented to the Board of Visitors of the University Observatory, and we learn from it that the photographic telescope, prepared for taking part in the International Chart of the Heavens, is at length complete. The guiding telescope also is provided with a micrometer sufficient to permit the observation of stars at a considerable distance from the centre of the plate, and the camera end of the telescope is fitted with the apparatus devised by the Astronomer-Royal, and executed by Sir Howard Grubb. The Oxford University Observatory is also provided with two *réseaux*, supplied through Dr. Vogel, of the Potsdam Observatory, and has very recently added to its equipment a measuring machine of great delicacy for the discussion of the plates taken in connection with the international scheme. Altogether the equipment of the Oxford University Observatory appears to be in a very forward state of preparedness, and Prof. Pritchard congratulates himself and the University that this equipment has entailed no unusual appeal to funds, on which there are so many claims, but has been supplied by the bounty of the late Dr. De La Rue, supplemented by strict economy in the management of the Observatory in former years. The astronomical work of the past year has been mainly confined to the discussion of the parallax of stars of the second magnitude,

and this work is now on the brink of accomplishment. Seven complete determinations, including that of β Aurigæ, have been made in the year, and but six other stars, the measures of which are complete, await discussion. Prof. Pritchard concludes his Report as usual, by acknowledging the aid he has received from his two assistants, and we are glad to see speaks hopefully of his restoration to complete health.

THE President of the French Republic inspected the meteorological instruments at the summit of the Eiffel Tower on June 13, and afterwards visited the Central Meteorological Office, where he witnessed M. Weyer's experiments on the formation of tornadoes, and also inspected the instruments which there register the indications of the meteorological phenomena at the top of the Eiffel Tower.

THE French Minister of Public Instruction has appointed Dr. Henry de Varigny, assistant in the Museum of Natural History, to report on the University Extension movement, and has commissioned him to study the question in Edinburgh, London, and Oxford.

THE proposed law on Universities is exciting a good deal of discussion in France. Many local jealousies have been aroused in connection with the question. Every town that boasts the possession of a tenth-rate medical school, or of an inadequate scientific faculty, wishes to have a University; and its political representatives have, of course, to do what they can to press its claims. On the other hand, the Government, which would willingly establish five or at most six large Universities, desires if possible, to do away with small and useless institutions.

A SCIENTIFIC expedition which has been organized in Maine is about to spend some time in Labrador. The principal object of the party will be to collect ethnological specimens. They will take with them a phonograph, with which they hope to obtain some materials for the study of the language and songs of the Eskimo.

IN drawing up schemes for the appropriation of the funds placed at their disposal under the Local Taxation Act, 1890, for the promotion of technical instruction, the County Councils certainly ought not to overlook the claims of girls' education. With a view of aiding County Councils in this department of their work, the Committee of the National Association for the Promotion of Technical and Secondary Education has submitted to them a careful outline of subjects which are adapted for girls, and included within the scope of the Technical Instruction Acts. It is suggested that in each county a committee of ladies should be appointed to devise and carry out a scheme for the technical education of girls.

THE *Sussex Daily News* of June 18 records the birth of a sea lion at the Brighton Aquarium.

ON June 18, sixty distinct shocks of earthquake occurred at Serajunge and Domar, in the Bengal Presidency. Many buildings were slightly damaged. At Serajunge continuous earthquake shocks had been felt from noon on the preceding day.

ACCORDING to a telegram from Rome, dated June 22, a strong shock of earthquake was felt that morning at Avigliano and at Aquila.

IN his report on the Royal Botanic Gardens, Ceylon, for 1890, Dr. Trimen refers to the kinds of cacao in cultivation there. There is no reason to suppose, he says, that they have under cultivation more than one species of *Theobroma*, but every probability that all the varieties trace their origin to a common wild parent. It would be interesting to know which of the two fairly well-marked races recognized in Ceylon is the nearer to this original type, and the facts could probably be ascertained in Central America. The names "Criollo" and "Forastero" applied to them simply mean "wild and foreign," and seem to have had their origin in Trinidad, but it is doubtful if the former

was ever really a native plant there. It was, however, the sort at one time exclusively grown in that island, where, having died out, its place was supplied by the "foreign" sort, no doubt obtained from the mainland. As seen in Ceylon, the "Criollo" (called also there "Caracas" and "Old Ceylon Red Cacao") presents very little variety, but the "Forastero" shows a remarkable range in form, size, and colour of pod and seed. No doubt crossing goes on freely in plantations even between the two main races, and it is well known in Ceylon that seed from a single tree gives a very varied progeny; but a curious remark was recently made to Dr. Trimen by a large grower, who has great opportunities for observation, that the "Forastero" varieties, which he chiefly cultivates, appear to be gradually changing their characters and becoming more like the "Old Ceylon Red," the seeds losing their dark colour on section, and becoming pale or nearly white.

IN *Himmel und Erde* for June, Prof. G. Hellmann, of Berlin, begins a series of articles entitled "Meteorologische Volksbücher," being an inquiry into popular and typical meteorological works from the earliest times, and into the nature of their contents. The works to be discussed are more particularly those of Germany, although foreign literature will also find subsidiary consideration. Two works are referred to in the present article:—(1) "The Book of Nature," by Konrad von Meigenberg, which is the oldest natural history in the German language, and was written about the year 1350—nearly a century before the invention of printing. It was first printed in 1475, and went through many subsequent editions. Much attention and original thought was given to meteorological subjects, and the author divided the wind-rose into 12 points; but the work is to some extent based upon a still unpublished Latin manuscript by Thomas Cantimpratensis, "Liber de natura rerum," which was written before the middle of the 13th century. (2) "Elucidarius." The author of this work is not known with certainty, but is supposed to be Jakob Köbel. This remarkable work was first published in German, in the year 1470, and was much sought for in most European countries in the 15th and 16th centuries. It deals with a variety of subjects, including meteorology and geography, and many editions were published in various countries. Dr. Hellmann gives copious extracts from the works; and historical research being a subject in which he carries great authority, his treatment of it will be found both interesting and instructive.

MESSRS. VIEWEG AND SON, of Brunswick, intend publishing a German translation of Mr. Denning's new book, "Telescopic Work for Starlight Evenings."

A WORK entitled "Synopsis der Höheren Mathematik," by J. G. Hagen, Director of the Georgetown College Observatory, Washington, D.C., is to be published by Felix L. Dames, Berlin. The work is the result of labour carried on continuously during twenty years, and is intended to present a general view of the higher mathematics. It will consist of four volumes, the first of which will be issued early in August.

A VALUABLE paper on gum-trees, by Mr. D. McAlpine and Mr. J. R. Remfry, has been reprinted from the Transactions of the Royal Society of Victoria for 1890. There are several illustrative plates, the drawings being principally reproductions of photographs taken by Mr. Remfry. These drawings show that the transverse section of the leaf-stalk of a Eucalypt may reveal a pattern useful in the determination of species.

MESSRS. GEORGE PHILIP AND SON have issued the first number of the *Blue Peter*, a monthly sailing list and review. It is intended that the new journal shall provide ample information for persons who are about to set out by any one of the principal ocean routes. There will also be articles which may serve to remind ships' officers that "there is substantial profit to be derived from a scientific training."

THE third volume of the *Photographic Recorder* is completed by the June number. The volume is admirably illustrated, and contains a valuable record of all that has been done in connection with photography during the past year.

MESSRS. W. F. BROWN AND CO., Montreal, are printing for the Government of Canada "Contributions to Canadian Palæontology," by J. F. Whiteaves, Palæontologist and Zoologist to the Canadian Survey. Part iii. of vol. i. has just been issued. It deals with the fossils of the Devonian rocks of the Mackenzie River basin.

A NOTE by M. Moissan upon the action of fluorine upon phosphorus trifluoride is communicated to the current number of the *Bulletin de la Société Chimique*. A short time ago M. Moissan described a mode of preparing the gaseous trifluoride of phosphorus. The method consisted in gradually adding phosphorus tribromide to warm zinc fluoride, washing the gas first through water, in which it is sparingly soluble, and afterwards drying by means of pumice moistened with sulphuric acid and collecting over mercury. In order to study the action of free fluorine gas upon phosphorus trifluoride as thus prepared, a special piece of apparatus was devised, constructed entirely of platinum and fluor-spar. It consisted of a platinum tube fifteen centimetres long, closed at each end by transparent plates of fluor-spar, through which the phenomena attending the reaction could be observed. The platinum tube was fitted with three side tubes, two of which were placed opposite each other about the centre of the tube, and served for the admission of the fluorine and phosphorus trifluoride respectively; the third or exit tube was of somewhat wider diameter than the entrance tubes, and was bent so as to serve as a delivery tube over a mercury trough. The whole apparatus was first filled with phosphorus trifluoride, and then the fluorine entrance tube was connected with M. Moissan's now well-known apparatus for the preparation of fluorine. As soon as the fluorine came in contact with the phosphorus trifluoride a yellow flame was produced and intense action occurred, with the production of phosphorus pentafluoride. The flame appears to be a comparatively low temperature one. On collecting the gaseous product over mercury, it was found to consist very largely of phosphorus pentafluoride, readily capable of absorption by water, and a small proportion of unaltered trifluoride which could be absorbed by potash. This reaction of fluorine with trifluoride of phosphorus is thus analogous to the conversion of phosphorus trichloride into pentachloride by the action of gaseous chlorine. An interesting reaction has also been observed by M. Moissan to occur between spongy platinum and these gaseous fluorides of phosphorus. When pentafluoride of phosphorus was passed over spongy platinum gently heated in a platinum tube, a partial decomposition was found to occur, and the issuing gas was admixed with trifluoride, and also with free fluorine. The existence of the latter in the free state was abundantly shown by its action upon crystallized silicon. When, however, the temperature of the tube was raised to dull redness, a volatile compound, containing platinum, phosphorus, and fluorine, was obtained, which was carried forward by the gaseous current and deposited in crystals in the cooler portion of the tube. When this crystalline substance is heated, it melts to a viscous liquid, which decomposes at a bright red heat. Analyses show that it is a fluorophosphide of platinum, probably of the composition $2PF_3.PtF_4$, analogous to one of the similar chlorine compounds discovered by Schützenberger, $2PCl_3.PtCl_4$. M. Moissan expresses the hope that by employing some such dissociating compound as this a purely chemical isolation of fluorine may some day be achieved.

THE additions to the Zoological Society's Gardens during the past week include three Stoats (*Mustela erminea*), European, presented by Mr. J. S. B. Borough; an Ocelot (*Felis pardalis* ♂) from South America, a Red-tailed Buzzard (*Buteo borealis*), a

Laughing Gull (*Larus atricilla*) from North America, presented by Sir Henry Blake, K.C.M.G.; a Tawny Eagle (*Aquila naevioides*) from Africa, presented by Mr. K. G. Hay; a Blue-fronted Amazon (*Chrysotis estiva*) from South America, presented by Mrs. A. G. Mussey; a Grey-breasted Parrakeet (*Bolborhynchus monachus*) from Monte Video, presented by Mr. J. R. George; four Common Quails (*Coturnix communis*), British, presented by Mr. J. C. Gie; two Chinese Geese (*Anser cygnoides*) from China, presented by Captain Creaghy; an Egyptian Gazelle (*Gazella dorcas*) from Egypt, two Abyssinian Guinea Fowls (*Numida ptilorhyncha*) from Abyssinia, two Blossom-headed Parrakeets (*Palæornis cyanocephalus*) from India, a Meyer's Parrot (*Psephenus meyeri*) from East Africa, three Tibetan Crossbills (*Crossoptilon tibetani*) from Tibet, a Temminck's Tragopan (*Cerionis temminckii* ♂) from China, deposited; a Vinaceous Amazon (*Chrysotis vinacea*), from Brazil, purchased; two Heloderms (*Heloderma suspectum*) from Arizona, U.S.A., received in exchange; a Burriel Wild Sheep (*Ovis burriel*), two Mule Deer (*Cariacus macrotis* ♂ ♀), a Bennett's Wallaby (*Halmaturus bennetti* ♂), two Impeyan Pheasants (*Lophophorus impeyanus*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

TRANSIT OF MERCURY.—The Government Astronomer at Sydney (Mr. C. Todd, C.M.G.) writes as follows regarding the transit of Mercury:—Good observations of the transit of Mercury were secured at the Observatory, on Sunday the 10th. At the ingress the conditions were extremely favourable, the sun's limb and the planet when projected on the sun's disk being exceedingly well and sharply defined, but at the egress the sun's limb was boiling and the planet was somewhat woolly, rendering it difficult to fix the exact time of internal contact. I observed with the 8-inch equatorial refractor, assisted by Mr. Cooke; and Mr. Sells observed with an 8-inch reflector.

The observations were as follow:—

Observer—C. Todd. Power 125.

INGRESS.—*External Contact.*

	Times.
	h. m. s.
A. About one-third on	9 10 11

Internal Contact.

B. Contact tangential	9 13 6.5
C. Black drop still clinging to limb	9 13 22.0
D. Rupture of black drop; planet clear of limb	9 13 49.5

EGRESS.—Power 80. *Internal Contact.*

E. Formation of black drop touching limb ...	2 0 14.1
F. Tangential contact	2 0 43.8

External Contact.

Indentation still visible	2 4 14.8
„ „ barely noticeable	2 4 25.8
Sun's limb complete	2 4 31.8

Observer—Mr. Sells.

INGRESS.—*Internal Contact.*

a. Planet nearly on disk, but not quite ...	9 12 51.3
b. True contact, momentarily seen	9 13 13.2
c. Planet pear-shaped; point of pear touching sun's limb	9 13 50.7

EGRESS.—*Internal Contact.*

a. Pear-shaped contact	2 0 34.6
b. True contact	2 1 28.6

External Contact.

c. Last seen; or sun's limb judged to be complete... ..	2 4 48.6
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OBSERVATIONS OF TELLURIC LINES.—The May number of the *Memorie della Società degli Spettroscopisti Italiani* contains a paper by G. B. Rizzo on the telluric lines in the solar spectrum. Signor Rizzo has compared the intensities of the lines A, B, and a at Bosco Nero and on the Rocciamelone Mountain. In order to express the variation in the mass of air (ϵ) traversed, calculations have been made of the values at the different altitudes of P sec ζ , where P is the atmospheric pressure, and ζ is the sun's zenith distance. The following is a comparison of the

values of ϵ and the mean intensities of the lines at the two stations. The scale of intensity is such that the C line = 10, and the line at 651.55 is unity.

Place of observation.	Altitude.	ϵ .	Intensities of the lines		
			A.	B.	α .
Bosco Nero ...	1623 metres ...	1046.2 ...	50	28	3.2
Rocciamelone ...	3538 ,, ...	846.2 ...	40	20	2.2

A comprehensive bibliography of the subject accompanies the paper.

SIMILARITY OF THE ORBITS OF CERTAIN ASTEROIDS.—In the *Publications of the Astronomical Society of the Pacific*, No. 15, 1891, Prof. Daniel Kirkwood gives a list of twenty-four asteroids arranged in ten groups, according to the similarity of their orbits. The following are the groups:—

I.	{	84 Clio.	VI.	{	3 Juno.
		115 Thyra.			97 Clotho.
II.	{	249 Ilse.	VII.	{	203 Pompeia.
		19 Fortuna.			200 Dynamene.
III.	{	79 Eurynome.	VIII.	{	278 Pauline.
		134 Sophrosyne.			116 Sirona.
IV.	{	193 Ambrosia.	IX.	{	1 Ceres.
		37 Fides.			245 Vera.
V.	{	66 Maia.	X.	{	86 Semele.
		218 Bianca.			106 Dione.
		204 Callisto.			121 Hermione.
		246 Asporina.			87 Sylvia.

Jupiter is held responsible for the perturbations necessary for the development of these groups of asteroid orbits from the primitive solar nebula.

ASTRONOMICAL AND PHYSICAL SOCIETY OF TORONTO.—The first number of the Transactions of this Society (1890-91), with which is also included the first Annual Report, has recently been issued. It contains abstracts of several interesting papers read at the meetings, among which is one on the disappearance of Saturn's rings, by Dr. Morrison, two by Mr. Shearman on coronal photography, and two by Mr. A. F. Miller on the spectroscope. A drawing of a sun-spot observed on November 30, and a hydrogen prominence measured on August 3, forms the frontispiece of the number.

A NEW ASTEROID (311).—On June 11 M. Charlois discovered the 311th asteroid. Its magnitude was 13.

THE ROYAL SOCIETY CONVERSAZIONE.

THE Ladies' Soirée of the Royal Society was held on the 17th instant, and was very numerously attended. The following were among the chief objects exhibited:—

Finger-prints as a means of identification, exhibited by Mr. Francis Galton, F.R.S. (1) Specimens showing the nature and character of the patterns that are formed by the papillary ridges on the bulbs of the fingers, as well as on the rest of the inner surfaces of the hands and feet. (2) Evidence of the persistence of the patterns in their essential details, however minute, from infancy to age. (3) Method of indexing a collection of finger-prints so that a determination may be quickly arrived at, whether the duplicate of a given specimen is contained in it or not. (4) Process of making finger-prints, exhibited in operation.

Registration of colours in numbers, and apparatus to show the greater sensitiveness of the eye to different colours, exhibited by Captain Abney, C.B., F.R.S., and General Festing, F.R.S. The registration consists in referring any mixed colour to a single wave-length, and a percentage of white light. With the apparatus to show the greater sensitiveness to the eye of different colours, a comparison is made by placing two colours side by side, which are at ordinary intensity of equal luminosity, and by then diminishing the intensity of each equally.

An optical illusion, exhibited by Prof. Silvanus P. Thompson, F.R.S. On two rotating disks, A and B, are spiral patterns in black and white, which seem to move radially inwards and outwards respectively. Let the observer gaze fixedly for about one minute at the centre of A, and then suddenly transfer his gaze to any object—say the face of a friend—he will see that object apparently enlarging from the middle outwards. After similarly gazing for a minute at B, and then looking at any object, he will see it apparently diminishing.

Discharge without electrodes through gases, exhibited by Prof. J. J. Thomson, F.R.S. The discharge tube in these experiments is made to form the secondary of what is essentially an induction coil, and the discharge passes round a closed current in the gas. Experiments *a, b, c, d* show various forms of the discharge in tubes and bulbs. *e* shows the residual glow produced when the discharge passes through oxygen. *f* shows the action of a magnetic field on the discharge; along the lines of force the discharge is facilitated, while at right angles to them it is retarded. When the magnetic field is "off," the discharge takes place in the bulb, and not in the tube; when the field is "on," in the tube, and not in the bulb. *g* illustrates the stoppage of the discharge when a gas electrically weaker than that in the discharge tube is placed in the neighbourhood of the latter.

A nickel pendulum, illustrating the effect of heat upon the magnetic susceptibility of nickel, exhibited by Mr. Shelford Bidwell, F.R.S. Nickel, which at ordinary temperatures is a magnetic metal, becomes non-magnetizable at about 300° C. A copper disk, to which a projecting tongue of nickel is attached, hangs like the bob of a pendulum from a double thread, and is deflected to one side by a magnet which attracts the nickel tongue. The heat of a spirit-lamp placed beneath the tongue quickly destroys the magnetic quality of the nickel, so that the magnet can no longer hold it; the bob accordingly falls back and performs an oscillation. On its return to the neighbourhood of the magnet, however, the tongue has cooled sufficiently to be once more attracted, but after a momentary contact it is again released, and the process is repeated. Thus the bob can be kept swinging like the pendulum of a clock.

The maldometer, exhibited by Mr. J. Joly. This instrument is for determining the melting-points of minute quantities of substances, by comparison with bodies of known melting-point. The method consists in measuring the thermal expansion of a ribbon of pure platinum when a minute quantity of a substance, dusted on its surface (and observed through a microscope), is melting. The platinum is heated by a current, and the thermal value in degrees Centigrade of its expansion found by preliminary observations, using bodies of known melting-point. The expansion of the ribbon is read by an electric-contact method. The instrument shown reads a change of 2° C. Range up to 1600° C. about. Quartz may be melted on the maldometer, and most or all of the silicated minerals.

Facsimile drawings of paintings from tombs at Beni Hasan, Upper Egypt, exhibited by Mr. Percy E. Newberry (of the Egypt Exploration Fund). A series of facsimile drawings in colour, executed by Mr. M. W. Blackden, of some of the most interesting paintings on the walls of the tombs of Ameni and Khnumhotep (XII. Dynasty, circa 2500 B.C.), at Beni Hasan, in Upper Egypt. These drawings are the property of the Egypt Exploration Fund.

Instrument for examining the strains in bent glass beams, exhibited by Prof. C. A. Carus-Wilson. There is a steel straining frame in which the beam to be examined is placed; this frame can be moved in any direction in its own plane between two Nicol prisms. The Nicol prisms can be rotated through any required angle. When the beam has been supported in any given manner, load is applied by a screw, and the action of the strained glass on the polarized light enables the precise state of strain all over the beam to be ascertained. The instrument has been used to determine the action of "surface loading," and to show to what extent this action affects the state of strain in beams supposed to obey the Bernoulli-Eulerian theory of flexure.

Cup-micrometer, an instrument for measuring the rate of growth of a plant, exhibited by Mr. Francis Darwin, F.R.S. A thread is attached to the upper end of the plant, passes over a pulley, and is fastened to a weight. The descent of the weight (which is a measure of the growth of the plant) is estimated by adjusting a micrometer screw carrying a small cup of oil, until a needle point on the weight touches the surface of the fluid. The method, a modification of that used by physicists to measure the rise or fall of a fluid surface, was designed by Mr. H. Darwin, of the Cambridge Scientific Instrument Company.

Electrical volatilization of metals, exhibited by Mr. W. Crookes, F.R.S.

Living animals from the aquarium of the Marine Biological Association at Plymouth, exhibited by the Marine Biological Association.

Art metal work, from the factories of Messrs. Tiffany and Co.,

in New York, exhibited by Messrs. Tiffany and Co. Representative articles in wrought metals; amalgamation of metals; enamelling on silver and gold.

Photographs of living corals taken in Torres Straits, exhibited by Mr. W. Savile Kent.

Prof. J. Norman Lockyer, F.R.S., exhibited:—(1) Photographs of a group of sun-spots. A series of enlargements of a group of sun-spots shown on the 12-inch sun-pictures taken under the direction of Lieut-Colonel Strahan, at Dehra Dun, India, on December 16, 18, 19, 20, 21, 22, 23, 1887. The spots have been enlarged three times, and it will be seen that great changes took place during the period of visibility.—(2) Photographs of the temples at Karnak and Edfou. These are enlargements from photographs taken in January 1891, with reference to the orientation of the temples. The photographs show that, notwithstanding the elaborate details of the architecture, the principal axes of the temples were kept perfectly clear from one end to the other.

Prof. W. Roberts-Austen, C.B., F.R.S., exhibited a new, brilliantly coloured alloy of gold and aluminium, and facsimiles of medals asserted to be of gold and of silver, transmuted from base metal by the aid of alchemy. One of the medals bears on its reverse the statement that it was struck in 1675, by J. J. Becher, in silver transmuted from lead.

Mr. Ludwig Mond, F.R.S., exhibited:—(1) Nickel-carbon-oxide. (2) Pure nickel extracted from nickel ores by means of carbonic oxide. (3) Articles of pure nickel deposited from nickel-carbon-oxide, and goods plated with nickel by exposure to nickel-carbon-oxide $[\text{Ni}(\text{CO})_4]$. This unique chemical compound was obtained in 1890 by Mond, Langer, and Quincke, by passing a current of carbonic oxide over finely-divided metallic nickel at the ordinary temperature, and refrigerating the resulting gas. It is a colourless liquid, of high refractory power, boiling at 43°C ., and solidifying at 25°C ., and is split up again into nickel and carbonic oxide on heating its vapour to 180°C . It is highly poisonous; while according to Prof. McKendrick's researches it has, when injected subcutaneously in very small doses, a remarkable power of reducing the temperature of animals. The properties of this substance make it possible to volatilize nickel at a low temperature, and to extract it industrially in a perfectly pure state from all other substances with which it is found. Articles of pure nickel, and goods plated with pure nickel, are produced by exposing heated moulds or goods to nickel-carbon-oxide vapour, or to a solution of this compound in suitable solvents.

Specimens of Japanese metal work, including *Ojimé*, or sliders, *Yanoné*, or arrowheads, and *Tsuba*, or sword-guards, exhibited by Prof. A. H. Church, F.R.S.

Prof. A. Newton, F.R.S., exhibited a drawing, the first received in Europe, of *Notoryctes typhlops*, a new form of Marsupial of mole-like habit, and structure accordingly, sent by Prof. E. C. Stirling, of the University of Adelaide, South Australia. The first specimen of this remarkable mammal, one of the most unexpected discoveries for many years, was sent from the interior of South Australia by Mr. A. Molineux to Prof. Stirling, of Adelaide, who contributed to NATURE (vol. xxxviii. pp. 588, 589) such a notice of it as its imperfect condition admitted. He afterwards obtained other examples, which are fully described in a memoir communicated to the Royal Society of Adelaide. "Four or five of the cervical vertebræ are fused, and there is a keeled sternum. An enormously thick and short first rib, which serves the purpose of buttressing the sternum in lieu of coracoids. Eyes mere pigment spots, underneath the skin and temporalis muscle. It has a remarkable habit of burrowing for long distances in the sand with great rapidity." These specimens were obtained about 1500 miles north of Adelaide, but a telegram from Prof. Stirling, dated May 31, 1891, states that he has himself obtained others in the course of a journey, just completed, across the continent from Port Darwin.

Mr. Walter Gardiner, F.R.S., gave demonstrations of certain important phenomena associated with the absorption and the flow of the water taken up by plants:—(1) Root pressure. Water present in the soil, and containing minute traces of nutritive salts, is absorbed by the root-hairs so powerfully and in such quantities as to set up a considerable pressure in the interior of the plant. This "root pressure" may be demonstrated by attaching to the cut end of a stem a manometer containing mercury, or some coloured fluid. Here a solution of nigrocine in water is employed. (2) The transpiration current.

Among the more important factors which determine the flow and ascent of water from the root, upwards, is the sucking force induced by the modified evaporation or transpiration of water from the general free surface of the leaves. During transpiration the water escapes as vapour, and the salts are retained for food. In this experiment the existence of a "transpiration current" is shown by allowing a cut branch to suck up milk, when the movement of the fat globules registers the flow of the liquid. (3) The amount of water absorbed by the root. This may be estimated by simple measurement, employing some such form of apparatus as that exhibited.

Engravings to "Travels among the Great Andes of the Equator," exhibited by Mr. Edward Whymper. These illustrations are selections from Mr. Edward Whymper's forthcoming work upon the Great Andes of the Equator (in which he gives accounts of the first ascents of Chimborazo, Cayambe, Antisana, &c., &c.), and includes views on and about the equator at great elevations; incidents of travel; numerous examples of the new genera and species obtained on the journey; a facsimile reproduction of the map of Don Pedro Maldonado (upon which existing maps of Ecuador are based), and the original route survey, and map of Chimborazo, made by the author. The work, with 200 illustrations and four maps, will be published in the present year by Mr. John Murray.

Mr. W. Bateson exhibited (1) models of double supernumerary legs and antennæ in beetles; (2) mechanical model showing the usual symmetry of double supernumerary appendages in beetles. Supernumerary appendages in beetles nearly always spring as branches from a normal appendage, and are generally double, being made up of two limbs more or less compounded together. The two extra limbs are always a *complementary pair*, one being structurally a right limb, while the other is left. Commonly the symmetry of the parts is arranged as follows:—(a) The two extra limbs and the normal one stand in one plane, one of the extra limbs being nearer to the normal limb and one remoter from it. (b) The nearer is in structure and position an image of the normal limb in a mirror at right angles to the plane in which the three limbs stand; and the remoter is an image of the nearer in another mirror beyond and parallel to the first. Thus the relations of the parts in their several positions may be represented by the mechanical model exhibited, in which the extra legs, revolving round the normal leg, take attitudes proper to the positions which they occupy relatively to the normal leg.

Prof. A. C. Haddon exhibited the geographical distribution, and the progressive and retrogressive evolution, of art and ornament in British New Guinea. The exhibit is designed to show that savage art can be studied as a branch of biology, and that it is only when so treated that it yields its most valuable results. Most savage and barbaric designs have only a very limited geographical range, and those which have a wide distribution can, in the majority of cases, be proved to be homoplastic and not homogenetic. The evolution of a particular pattern must be sought in the district in which it occurs, and its developmental history can only be safely attempted when a comparison is made of numerous objects from the same locality. The foregoing propositions are illustrated by means of specimens, rubbings, photographs, and sketches of decorated objects from British New Guinea.

At intervals during the evening, the Edison loud-speaking telephone and Bell's receivers were connected with the performance of "The Gondoliers," at the Savoy Theatre, London; the Prince's Theatre, Birmingham; and with vocal and instrumental concert rooms at Liverpool and Birmingham.

Photographs of volcanic phenomena were exhibited by Dr. Tempest Anderson during the evening. These photographs of volcanic phenomena were taken last year during a visit to the Skaptá Jokul, and other volcanic districts in Iceland. The eruption of the Skaptá Jokul, in 1783, was one of the largest on record. A mass of lava, estimated to be equal in bulk to Mont Blanc, flowed out in two streams, each forty to fifty miles long. The actual craters situated in the desert interior of the island appear not to have been previously visited.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The following are the speeches delivered by the Public Orator (Dr. Sandys, Fellow and Tutor of St. John's

College) on June 16, in presenting for the honorary degree of Doctor in Science Sir Archibald Geikie, F.R.S., Director-General of the Geological Survey of Great Britain and Ireland; Mr. W. H. Flower, C.B., F.R.S., Director of the Natural History Museum; and Dr. Elias Metschnikoff, *Chef de Service* of the Institut Pasteur, Paris.

Salutamus deinceps virum et scientiarum et litterarum laude illustrem, in Academia Edinensi quondam Geologiae Professorem, Britanniae et Hiberniae explorationi geologicae praepositum, societatis Regiae socium, societatis geologicae praesidem, societatis denique Britannicae scientiarum terminis prorogandis praesidem designatum. Geologiae et geographiae studiosorum in manibus sunt scripta eius plurima, scientiis illis aut docendis aut illustrandis destinata. Etiam aliis loquuntur libri eius elegantissime conscripti, quorum in uno Caledoniae montes vallesque per immensam saeculorum seriem causis cotidianis minutatim excelsas fuisse demonstrat; in altero vitam et regestias geologi magni, quem Siluriae regem nominaverim, ea quae par est dignitate describit. Viri talis laboribus non modo geologiae fines latius indies propagantur, sed etiam populo universo studia illa praeclara commendantur.

Duco ad vos geologum illustrem, ab ipsa Regina nuper novo honore ornatum, ARCHIBALDUM GEIKIE.

Quod e sapientibus septem unus dixisse fertur, ἀρχὴ ἄνδρα δελεῖ, de hoc certe viro, per honorum cursum satis longum probato, verum esse constat. Regio Chirurgorum in Collegio, primum Museo conservando praepositus, deinde physiologiam et comparativam quae dicitur anatomiam professus, deinceps Musei Britannici aedificio novo rerum naturae studiis dedicato praefectus est. Idem societati et zoologicae, et anthropologicae, et Britannicae, maxima cum laude praefuit. In Museis autem ordinandis quam perspicax; in scientiarum studiis populo toti commendandis quam disertus; hominum in diversis generibus capitis mensura inter sese distinguendis quam subtilis; maris denique in monstris immensis describendis quam minutus. Ergo, velut alter Neptunus, intra regni sui fines etiam "immania cetera" suo sibi iure vindicat: idem, anthropologiae quoque in studiis versatus, ne barbaras quidem gentes contempsit, sed, velut alter Chremes, homo est; humani nil a se alienum putat.

Duco ad vos Regiae societatis socium, virum honoribus plurimis merito cumulatum, WILHELMUM HENRICUM FLOWER.

Sequitur deinceps vir, qui scientiarum in provinciis duabus, et in zoologia et in bacteriologia quae dicitur, famam insignem est adeptus. Primum Ponti Euxini in litore septentrionali zoologiam professus, multa de morphologia animalium, quae invertebrata nominantur, accuratissime disseruit. Deinde Parisiis rerum naturae investigatori celeberrimo adiutor datus, eis potissimum causis perscrutandis operam dedit, per quas genere ab humano morborum impetus hostiles possent propulsari. Nam, velut hominum in mentibus virtutes et vitia inter sese confligunt, non aliter animantium in corporibus contra pestium exercitus copiae quaedam sanitatis et salutis ministras concertare perhibentur. Mentis quidem certamen olim in carmine heroico, Psychomachia nominato, Prudentius narravit. Inter eos autem qui corporis certamen experimentis exquisitis nuper explicaverunt, locum insignem sibi vindicat vir quidam summa morum modestia praeditus, qui, velut vates sacer, proelium illud sibi sumpsit celebrandum, in quo tot cellulae vagantes, quasi milites procurantes, morborum semina maligna corripunt, correpta comprimunt, compressa extinguunt. Talium virorum auxilio febrium cohortes paulatim profragantur, et generis humani salutis novum indies affertur incrementum.

Merito igitur titulo nostro hodie coronatur e salutis humanae ministris unus, ELIAS METSCHNIKOFF.

At the annual election at St. John's College on June 22 the following awards in Natural Science were made:—Foundation Scholarships, continued or increased: P. Horton-Smith, Hewitt, Blackman, Woods, MacBride, Whipple. Foundation Scholarship awarded: Villy. Exhibitions: Purvis, Trotman. Hughes Prize: MacBride. Wright's Prize: Villy. In the Natural Sciences Tripos, Part II., Capstick, of Trinity, has been awarded "special distinction" in two subjects, Chemistry and Physics. It is many years since this last occurred. MacBride, of St. John's (Zoology, Botany), and Krishnan, of Christ's (Chemistry, Botany), have gained first classes in two subjects. Of the women candidates, Miss Elliot, of Newnham (Zoology), and Miss Tebb, of Girton (Physiology), have gained first class honours.

SCIENTIFIC SERIALS.

American Journal of Science, June.—The study of the earth's figure by means of the pendulum, by E. D. Preston. The author first deals with the history of the subject, then states the quantities involved, and supports the method of study in which the figure of the earth is considered separately from its size as determined by measurement of arcs of meridian. The general results of pendulum work are discussed, and the effect of continental attraction and variations in latitude referred to. The best methods of determining the duration of a pendulum oscillation at a given temperature and pressure are also considered.—On the post-glacial history of the Hudson River valley, by Frederick J. H. Merrill. The result of the action of waves upon a shore depends upon the state of rest or movement of the shore. If the land is subject to alternate periods of rest and elevation, a series of terraces will be formed; if the land is slowly rising or subsiding with respect to sea-level, an inclined plane of erosion may be produced. Arguing from this and other facts, the author states provisionally that, after the retreat of the continental glacier from the Hudson River valley, the land stood for a long time at a lower level than at present. A gradual elevation and extensive erosion of the Champlain estuary deposits in the river valley then occurred, and was followed by a depression amounting to about 100 feet at New York, and which is apparently continuing at the present day.—On alunite and diaspore from the Rosita Hills, Colorado, by Whitman Cross.—Diaspore crystals, by W. H. Melville.—Combustion of gas jets under pressure, by R. W. Wood. Anyone who has watched a burning jet of ether vapour will have noticed that, as the pressure increases, the flame gradually retreats from the orifice and eventually goes out if the pressure is carried beyond a certain point. The author has investigated these phenomena, using various gases. A burning jet of coal gas was extinguished when the pressure was equal to 23 centimetres of mercury—that is, when the velocity of the issuing gas exceeded the speed of combustion for the mixture of gas and air.—Allotropic silver: Part iii., blue silver, soluble and insoluble forms, by M. Carey Lea. From the results given in this and preceding papers, the author is led to believe that allotropic and even soluble silver may be formed in numerous ways. The reducing agents may be either a ferrous or a stannous salt, or any one of a variety of organic substances of very different constitutions. From the solubility and activity of this substance, and the parallelism which many of its reactions show to those of silver in combination, it appears probable that silver in solution, like silver in combination, exists in the atomic form.—Note on the submarine channel of the Hudson River, and other evidences of post-glacial subsidence of the middle Atlantic coast region, by A. Lindenkohl.—Are there glacial records in the Newark system?, by Israel C. Russell. Facts are adduced in support of the negative view.—A reply to Prof. Nipher on the theory of the solar corona, by F. H. Bigelow.—On the recent eruption of Kilauea, by W. T. Brigham. This is a report of the changes that took place in the crater of Kilauea during March of this year.—Turquoise in south-western New Mexico, by Charles H. Snow.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 18.—"Results of Hemisection of the Spinal Cord in Monkeys." By Frederick W. Mott, M.D., B.S., M.R.C.P. Communicated by Prof. Schäfer, F.R.S.

While engaged in studying experimentally the connections of the cells of Clarke's column with the ascending tracts of the spinal cord in the monkey, I was surprised to find that after hemisection in the lower dorsal region the sensory disturbances produced in no way corresponded with those already obtained by eminent observers.

I was therefore led to continue my experiments, and, by the kind permission of Prof. Schäfer, I carried them out in the Physiological Laboratory of University College. My thanks are also due to him for much valuable advice and assistance.

The subject is one of great importance from a scientific, as well as from a clinical, point of view. Some years ago, a case occurred in my practice which tended to shake my faith in the absolute truth of the doctrine of complete and immediate decus-

sation of sensory impulses in the spinal cord, as taught by Brown-Séquard.

The experiments which I have performed exhibit the following principal points of interest:—

(1) Return of associated movements after complete destruction of the crossed pyramidal tract below the lesion.

(2) That all sensory impulses do not decussate in the cord—in fact, they appear to show that certain sensory impulses, e.g. touch, the muscular sense, and localization in space, pass chiefly up the same side, painful impressions up both sides. A peculiar condition known as "alochiria" occurs after hemisection.

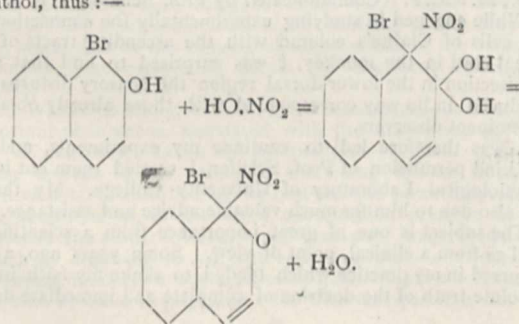
(3) The vaso-motor disturbances are on the same side as the lesion, and consist of vaso-dilation, swelling of the foot, and redness with rise of temperature of the skin of the foot (as compared with the opposite side), and fall of temperature in the popliteal space on the side of the lesion, due, no doubt, to paralysis of the muscles.

(4) The degenerations above and below the lesion are limited to the same side when the injury is perfectly unilateral. There are certain facts connected with the degenerations which serve to show the origin and course of certain long and short tract fibres.

(5) Stimulation of the cortex cerebri on both sides some weeks or months after the hemisection had been performed gave, as a rule, results which showed that the block in the spinal cord produced by the hemisection still existed, although there had been a very complete return of associated movements.

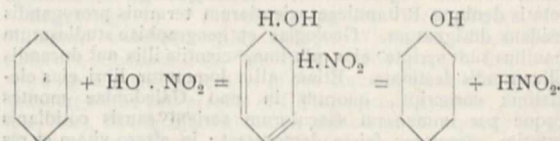
(6) In one case ablation of the leg area on the same side as the lesion in the spinal cord was performed many months afterwards.

Chemical Society, May 21.—Prof. A. Crum Brown, F.R.S., President, in the chair.—The following papers were read:—Bromo-derivatives of betanaphthol, by H. E. Armstrong and E. C. Rossiter. The authors have completed the study of the compounds formed on brominating betanaphthol, to which they have referred in two previous notices (Chem. Soc. Proceedings, 1889, p. 71; 1890, p. 32). In the present paper they give directions for preparing tri- and tetra-bromobetanaphthol, and summarize the properties of the bromobetanaphthols. The entire product of the action of bromine in excess on betanaphthol, has been carefully examined without any substance having been discovered which affords 1 : 2 : 3-bromophthalic acid on oxidation; the discrepancy between the authors' observations and the earlier experiments of Smith and Meldola, therefore, yet remains to be discovered.—The action of nitric acid on naphthol derivatives, as indicative of the manner in which nitration is effected in the case of benzenoid compounds generally: the formation of nitro-keto-compounds, by H. E. Armstrong and E. C. Rossiter. The chloro- and bromo-derivatives of betanaphthol when warmed with nitric acid are converted into derivatives of betanaphthoquinone; but the formation of these compounds is preceded by that of an unstable intermediate compound. These intermediate compounds, when carefully heated, are converted into derivatives of betanaphthoquinone. Thus, when nitric acid is added to dibromobetanaphthol, suspended in acetic acid, a clear solution is obtained which, after a short time, deposits a crystalline substance; if quickly evaporated by filtration, this product is almost colourless, but it decomposes when kept, becoming yellow. This compound, when treated with alkali, yields bromonitronaphthol. Bromobetanaphthol, in like manner, yields α_1 -nitro-betanaphthol, and the tri- and tetra-bromo-derivatives yield di- and tri-bromonitro-betanaphthol. The authors are of opinion that the intermediate compounds in question are nitro-bromo-keto-derivatives, and that their formation affords evidence that the elements of nitric acid first become added to the bromonaphthol, thus:—



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The theory that the formation of such addition-compounds precedes that of nitro-compounds generally, appears to afford a satisfactory explanation of a number of well-known facts which hitherto have remained unexplained. The non-production of nitro-compounds from paraffins and their derivatives appears as the natural consequence of the inability of paraffins to form addition-compounds. The theory affords a simple explanation of the formation of nitro-derivatives of phenols on nitrating hydrocarbons, for if the addition-compound lose $\text{H} \cdot \text{NO}_2$ instead of $\text{H} \cdot \text{OH}$ a phenol would result, thus—



An agent which would tend to withdraw water from the addition-compound would increase the production of nitro-compound and diminish that of phenol; and it is known that when a mixture of nitric and sulphuric acids is used, there is less of the phenol derivative produced than when nitric acid alone is employed. A compound like the addition-compound of benzene, represented above, would obviously be unstable, and prone to undergo oxidation; hence the explanation of the large amount of nitrous fume produced on nitrating benzene. The non-production of resinous matters when sulpho-acids are treated with nitric acid to form the corresponding nitro-compound by displacement of the SO_3H group by NO_2 is also elucidated by the authors' theory; the addition-compound formed in such a case would very readily break up into sulphuric acid and the nitro-derivative.—A new method of preparing nitro-derivatives, and the use of nitrogen dioxide as a nitrating agent, by H. E. Armstrong and E. C. Rossiter. The authors find that the unstable compounds formed by the addition of the elements of nitric acid to the bromo-derivatives of betanaphthol yield nitro-derivatives of the naphthol on treatment with alkali, a bromine atom becoming displaced by NO_2 . On treating the addition-compound with sulphurous acid, a practically theoretical yield of the nitronaphthol is obtained; this method appears to be of general application. The authors have been naturally led to study the action of nitrogen-dioxide, NO_2 , on unsaturated compounds of various kinds, in the hope of obtaining addition-compounds which by loss of HNO_2 would pass over into nitro-derivatives of the substances treated. They find that such addition-compounds are obtained, and on treatment with alkali and reducing-agents yield nitro-compounds. Thus betanaphthol yields 75 per cent. of its weight of nitro-betanaphthol; alphanaphthol behaves similarly. Phenol yields ortho- and para-nitrophenol. The authors propose to study the action of nitric acid and nitrogen dioxide on unsaturated compounds generally from the point of view indicated in this and the previous note.—Nitrification, by R. Warington. The first section of the paper describes early experiments, showing the existence of an agent producing only nitrites, and the means of separating it from soil. Successive cultivation in ammoniacal solutions made permanently alkaline with disodium carbonate was found to be a certain method of obtaining a purely nitrous agent. Pasture soil yielded the nitrous agent more readily than arable soil. The nitrous organism was isolated by the dilution method. Cultivations were made in an ammonium chloride solution with calcium carbonate. The nitrous organism oxidizes ammonia to nitrous acid, and has no effect on nitrites. It produces nitrous acid in solutions of asparagine, milk, urine, and urea. Grown in broth containing calcium nitrate, it does not reduce the nitrate to nitrite. It requires no organic matter for its nutrition, and is apparently capable of assimilating carbon from acid carbonates. The presence of either calcium or sodium acid carbonate distinctly favours nitrification; neutral sodium carbonate greatly hinders nitrification. The nitrous organism occurs as nearly circular corpuscles, which stain deeply. It also occurs as oval cocci, the ends occasionally more or less truncated. The remainder of the paper deals with the nitric organism. The results show that the nitric organism develops freely in inorganic solutions containing potassium nitrite, phosphates, &c., especially if supercarbonates are present. Monosodium carbonate, 1-4 grams per litre, exerted a very favourable influence; 6 grams per litre, a retarding influence. Disodium carbonate greatly hinders the action. The nitric organism produces neither nitrites nor nitrates in ammoniacal solution. In the absence of

ammonia, it energetically converts nitrites into nitrates; the presence of ammonia is apparently a great hindrance to its action. An attempt to isolate the organism failed. The nitrification performed by soil thus appears to be the work of two organisms, one of which oxidizes ammonia to nitrite, while the other oxidizes nitrite to nitrate.

Geological Society, June 10.—Sir Archibald Geikie, F.R.S., President, in the chair.—Before the commencement of the general business, Prof. Blake rose on behalf of those present at the meeting to congratulate the President on the honour that it had pleased Her Majesty to confer upon him. No one who knew him could fail to appreciate how thoroughly it was deserved; and the Geological Society would doubtless feel also the honour conferred on their science in the person of their President and the head of the Geological Survey of the United Kingdom.—The following communications were read:—Note on some recent excavations in the Wellington College district, by the Rev. A. Irving.—Notes on some post-Tertiary marine deposits on the south coast of England, by Mr. Alfred Bell. Communicated by Mr. R. Etheridge, F.R.S. The author's object in this paper is to trace the successive stages in the development of the present coast of the north side of the English Channel, and to ascertain the sources of the diversified faunas. The first traces of marine action on the south coast in post-Tertiary times, are found on the foreshore in Bracklesham Bay. The author's reading of the section is somewhat different from that of the late Mr. Godwin-Austen; and he divides the marine series into (1) an estuarine clay with Mollusca common to estuarine flats; (2) a compact hard mud; and (3) a bed of fine sandy silt with many organisms. These beds indicate a change from estuarine to deep-water conditions. A full list of the Selsey fossils is given, including, amongst other animals, upwards of 200 Mollusca. Of 35 species of Mollusca not now living in Britain, the majority exist in Lusitanian, Mediterranean, or African waters; furthermore, nearly 45 per cent. of the Mollusca are common to the older Crags of the eastern counties. The author considers the fauna of the Portland Bill shell-beds to indicate the further opening of the Channel subsequent to the formation of the Severn Straits, and believes that this fauna represents the deposits wanting between the Selsey mud-deposits and the erratic blocks which, according to him, overlie the mud; these Portland shells indicate an intermediate temperature, "rather southern than northern," according to Dr. Gwyn Jeffreys. In conclusion, details concerning still newer beds are given, and lists of fossils found therein; and the author observes that there is no evidence to show when the English Channel finally opened up, beyond the suggestion of Mr. Godwin-Austen that, if the Sangatte beds and the Coombe Rock are of the same period, it must have taken place after their formation. After the reading of this paper some remarks were made by Mr. Etheridge, Mr. C. Reid, Prof. Hull, and the author.

Mathematical Society, June 11.—Prof. Greenhill, F.R.S., President, in the chair.—The following communications were made:—Systems of spherical harmonics, by E. W. Hobson.—On the motion of a liquid ellipsoid under its own attraction, by Dr. M. J. M. Hill.—On certain properties of symmetric, skew-symmetric, and orthogonal matrices, by Dr. H. Taber.—An application of the method of images to the conduction of heat, by G. H. Bryan.—A property of the circum-circle, by R. Tucker.

CAMBRIDGE.

Philosophical Society, June 1.—Prof. G. H. Darwin, President, in the chair.—The following communications were made:—On the part of the parallactic series of inequalities in the moon's motion which is a function of the ratio of the mean motions of the sun and moon, by Mr. Ernest W. Brown.—On Pascal's hexagram, by Mr. H. W. Richmond. The author applies Cremona's method of deriving the hexagram by projection of the lines on a nodal cubic surface from the node. By use of a new form of the equation to this surface the equations of the lines are obtained in a perfectly symmetrical form, and their properties thence developed.—A linkage for describing lemniscates and other inverses of conic sections, by Mr. R. S. Cole.—Some experiments on liquid electrodes in vacuum tubes, by Mr. C. Chree. This paper describes some experiments undertaken at the suggestion of Prof. J. J. Thomson on the electric discharge through vacuum tubes in which one or both of the electrodes were liquid surfaces. The liquids employed were mercury and sulphuric acid. The electrodes when solid were

of platinum or aluminium. Observations were taken of the differences presented by the discharge when the substance of an electrode was altered. The experiments were mostly at low gaseous pressures, and included observations on the character of the phosphorescence then accompanying the discharge.—On gold-tin alloys, by Mr. A. P. Laurie.—Note on a problem in the linear conduction of heat, by Mr. G. H. Bryan.

EDINBURGH.

Royal Society, June 1.—Prof. Chrystal, Vice-President, in the chair.—Prof. Tait communicated a paper, by Prof. Piazzzi Smyth, on two series of enlarged photographs, one in the visible, the other in the invisible, of the violet of the solar spectrum. The paper was accompanied by the photographs. The observations include part of the spectrum as previously observed by Mr. Smyth in the summer of 1884, and extend to an extreme distance in the invisible violet. The previous observations were included in sixty plates; in the present series, twelve more plates are added in the violet region, and two independent photographs of each part have been taken. The photographs agree with those of Prof. Rowland in indicating that the Fraunhofer line, "little *d*," is either entirely absent now from the solar spectrum, or has become very unimportant.—Mr. R. Kidston read a paper on the fossil plants of the Kilmarnock, Galston, and Kilwinning coal-field in Ayrshire. All the species which are described in the paper belong, with one exception, to the Lower Coal-measures.—Prof. Tait communicated the second and third parts of a paper, by Prof. C. G. Knott, on some relations between magnetism and twist in iron, nickel, and cobalt. Part II. contains a continuation of former experiments on the twists produced in the magnetic metals when they are under the combined influence of circular and longitudinal magnetizations. A rectangular rod of cobalt twists, like nickel, left-handedly, when a current is passed along it in the direction of magnetization. Iron twists right-handedly, unless strong fields are employed. There is no reversal of the twist in nickel when strong fields are used, but a maximum can be reached. The magnitude of the twist which is produced by a reversal of one force depends upon which force is reversed. In general, reversal of the longitudinal field produces the greater effect; but iron and nickel, in low fields, twist most when the current is reversed. Hysteresis is very evident in all the phenomena. Evidence is given in this part in confirmation of the truth of an expression, which was given in Part I., for the twist in terms of the elongations in a thin-walled tube of given radius. Part III. contains a discussion of the magnetic consequences of twisting a magnetized wire—more especially a circularly-magnetized wire. The peculiar manner in which the magnetic change sometimes lags behind the stress, sometimes shoots ahead of it, is fully investigated. This effect is found to depend upon the strength of the current, on the amount of the twist, and on the amount of vibration to which the wire is subjected. The longitudinal polarity which is acquired when a wire carrying a current is twisted appears to be high in comparison with the intensity induced at the circumference of the wire. This seems to indicate the existence of molecular groupings which alter their configuration when subjected to change of stress or of magnetic force. The effects which are observed when an apparently demagnetized wire is subjected to twist suggest that a magnetized wire may in certain circumstances consist of alternate layers of opposite polarities. Any stress which acts differently on these layers will produce powerful magnetic effects. From his own experiments and those of other observers, Dr. Knott concludes that the first effect of a shearing stress on the molecular groupings is not only to increase the average intensity in the direction of the magnetizing force, but also to bring into prominence a relatively high intensity in directions at right angles to it.—Dr. Buchan communicated a paper by Mr. R. T. Omond, Superintendent of the Ben Nevis Observatory, and by Mr. A. Rankin, assistant observer, on the winds of Ben Nevis. The exact determination of northerly winds is not very easy, owing to the shape of the hill. The cliff, 2000 feet in height, which forms the northern face, breaks these winds up, and makes them squally and uncertain. Some may be entered on the record as north when they should really have been entered as north-east or north-west. Southern winds are on the whole slightly more frequent than northerly winds are. At sea-level the most frequent wind is west; and south-west, west, and north-west include nearly half of the total observations—more than half if calms are excluded. These low-level winds are in exact accord-

ance with the distribution of barometric pressure over the British Isles according to the Buys Ballot's law, which asserts that the winds blow counter-clockwise round areas of low pressure, such an area lying to the north of the British Isles. But the Ben Nevis winds do not fit in with such a distribution of pressure at all, which indicates that isobars drawn at the level of Ben Nevis (4400 feet) have directions differing entirely from the directions of sea-level isobars. In other words, the distribution of average barometric pressure which extends over the North Atlantic and North-western Europe, and dominates the surface wind over that area, does not in this country extend to a vertical height of one mile. Precautions were taken to make certain that this difference was not due to a difference between the methods of observation at Ben Nevis and at low-level stations. If a cyclonic storm of small area is lying to the north-eastward, the sea-level winds are west or north-west; but the Ben Nevis winds may be north-east, blowing straight out from the centre of the area of low pressure. In larger storms the Ben Nevis winds are practically identical with the sea-level winds, which indicates that a storm has a vertical extent proportionate in some way to the horizontal area which it covers. The outflowing wind seldom or never occurs when the centre is to the south or west, but only when it is to the north or east; and it is most strongly marked when an anticyclone lies on the other side. The outflowing current seems to carry the ascending air of the cyclone to the descending anticyclonic regions. The non-observation of the outward current when the centre of the cyclone lies on the south or west may be due to the fact that it passes at a higher level than the top of the mountain, for it then consists of air passing from hotter to colder regions, which will presumably rise to a higher level. The veering of the wind at great heights, which should occur according to the usual theory of cyclones, is very rarely observed.—Dr. Crum Brown read a paper, by Dr. A. B. Griffiths, on the blood of the Invertebrata.

PARIS.

Academy of Sciences, June 15.—M. Duchartre in the chair.—On the deformation and extinction of isolated or periodic aerial waves propagated in the interior of delivery tubes without water and of indefinite length, by M. J. Boussinesq.—On a volatile compound of iron and carbonic oxide-iron-carbonyl, and on nickel-carbonyl, by M. M. Berthelot. The author finds that iron, taken in a particular state, combines directly with carbonic oxide at ordinary temperatures (about 45° C. gives the best results) to form a very volatile compound. The required state is attained by reducing precipitated iron peroxide by hydrogen, or by decomposing ferrous oxalate by heat, and completing the reduction with hydrogen. Iron-carbonyl is analogous to nickel-carbonyl, discovered by Mond, Lang, and Quincke (Journ. Chem. Soc., vol. lvii. p. 749, 1890). M. Berthelot has investigated the stability of the latter compound and its reactions with oxygen, sulphuric acid, ammonia, and nitrogen dioxide.—*Résumé* of meteorological observations made at Ecorchebœuf, near Dieppe, from 1873 to 1882 by M. J. Reiset.—Observations of Wolf's periodic comet, made at Paris Observatory (West Tower equatorial), by M. G. Bigourdan. Two observations for position were made on June 12. It is remarked that the comet is a round nebulosity about 20' in diameter, and having a magnitude 13.3.—Observations of the new asteroid (310) made at Paris Observatory with the East Tower equatorial, by Mdlle. D. Klumpke. An observation for position was made on June 12.—Eclipse of the sun of June 6; observations made at Lyons Observatory, by MM. Gonnèsiat and Le Cadet. Measures were made of times of contact.—Observations of Wolf's periodic comet (1884, III.), made at Algiers Observatory with the Foucault telescope of 0.50 metres aperture, by MM. Rambaud and Sy. Eight observations for position were made between May 15 and June 8.—Eclipse of the sun of June 6, observed at the Observatory of the Flammarion Scientific Society at Marseilles, by M. Jacques Léotard.—On the two forms in which the co-ordinates of the surface of the fourth degree, described by the summits of cones of the second order which pass through six given points, are expressed by means of θ functions of two arguments, by M. F. Caspary.—On an electric indicator for the detection of small variations of pressure in currents of gas, by MM. G. and L. Richard.—Researches on the application of the measure of rotatory power to the determination of compounds formed by aqueous solutions of mannite, with acid molybdates of soda and ammonium,

by M. D. Gernez. By measuring the proportions of salts in solution which give the maximum rotatory effect on polarized light, the author arrives at the molecular formula of the compounds formed.—On quinethyline, a homologous base of quinine, by MM. E. Grimaux and A. Arnaud.—On ureides derived from normal acids, by M. C. Matignon.—Mode of formation of methyl-campho-carbonates of methyl and ethyl, by M. J. Minguin.—On nitro-cyanacetic ethers, by M. P. Th. Muller.—Bleaching of cotton by oxygenated water, by M. Prud'homme. The addition of calcined magnesia to oxygenated water improves the bleaching properties of the latter. According to the author, the superiority of the results obtained is due to the formation of a peroxide of magnesium.—*Rôle* of the nucleus in the formation of the fundamental muscular reticulum of the larva of Phrygane, by M. G. Bataillon.—On a special disposition of the eyes in *Pulmonara basommatophora*, M. Victor Willem.—Experimental contribution to the study of growth, by M. Henry de Varigny.—On a cryptogamic disease of the *Acridium peregrinum*, by M. L. Trabut.—On the existence of a little Miocene vertebrate fauna in the rocks of the Saône valley at Gray, and at Mont d'Or Lyonnais, by M. Charles Depéret.—Contribution to the geological study of the environs of Digne, by M. Bachelard.—Fauna in a deposit of Quaternary strata at the environs of Pouillenay, by Don Jehl.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

The Oyster: W. K. Brooks (Wesley).—De l'Exercice chez les Adultes: Dr. F. Legrange (Paris, Alcan).—Bulletin of the United States Fish Commission, vol. viii. (Washington).—Education and Heredity: J. M. Guyau; translated by W. J. Greenstreet (Scott).—An Introduction to the Mathematical Theory of Electricity and Magnetism: W. T. A. Emtage (Clarendon Press).—Le Pêche et les Poissons des Eaux Douces: A. Locard (Paris, Baillière).—La Plume des Oiseaux: Lacroix-Danliard (Paris, Baillière).—Les Plantes d'Appartement et les Plantes de Fenêtres: D. Bois (Paris, Baillière).—Dictionnaire d'Electricité et de Magnétisme: J. Lefèvre (Paris, Baillière).—Bibliography of the Chemical Influence of Light: Dr. A. Tuckerman (Washington).—Constance Naden and Hylö-Idealism: E. B. Brewer (Bickers).—A Summary of the Darwinian Theory of the Origin of Species: F. P. Pascoe (Taylor and Francis).—L'Anthropologie, 1891, tome ii. No. 3 (Paris, G. Masson).—Journal of the Royal Microscopical Society, June (Williams and Norgate).

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