THURSDAY, MAY 28, 1891.

MEDICAL RESEARCH AT EDINBURGH.

Laboratory Reports of the Royal College of Physicians of Edinburgh. Vol. III. (Edinburgh and London: Young J. Pentland, 1891.)

NOW that for three years the laboratory of the Edinburgh Royal College of Physicians has shown steady advancement in every direction—in the number of workers engaged within it, in the volume of work accomplished, and more especially in the quality of that work—Dr. Grainger Stewart and his Council must congratulate themselves heartily that they were undeterred by any misgivings from entering upon a venture which has been so abundantly successful, and which has added so much to the renown of the College. It must be a source of very sincere satisfaction to them, and especially to Dr. Batty Tuke, the prime mover in its organization, to know that no laboratory in the Kingdom can show for the same space of time a record of so much good work in so many directions, of which a large part would never have been undertaken had this laboratory not been established.

In many respects the present volume exhibits marked improvement as compared with its predecessors. While composed of more than a dozen papers, these only represent but a portion of the investigations that have been completed, and all of them contain matter of permanent interest; others whose interest is of a more temporary nature have, I think wisely, been excluded. The value of the volume is further enhanced greatly by the fact that the majority of the reports appear here for the first time. Among these may be mentioned Dr. Helme's important contribution to the physiology of the uterus; Dr. Gulland's heterodox papers upon leucocytes and adenoid tissue; Noël Paton and Balfour's very full studies upon the composition and physiological action of the human bile; Woodhead and Cartwright Wood's observations upon bacterio-therapeutics; and a short but important communication by Cartwright Wood and Maxwell Ross on the influence which the process of inflammation exerts upon the course of infectious disease.

Taking these in order, Dr. Helme's paper is of especial value, not only clinically, from the light it throws on the mode by which certain drugs act upon the uterus, and from the consequent indications it affords as to the conditions under which they may wisely be administered, but also as a contribution to the physiology of non-striped voluntary muscle. Employing the *überlebende* organ—the organ removed with all precautions immediately after the death of the animal (a sheep)—and continuing the circulation through it artificially, Dr. Helme has been able to study its slow rhythmic contractions apart from the influence of the central nervous system and of the changes in the blood supply. From a physiological point of view, his most important observation is perhaps that which brings out the striking difference existing between striped and non-striped muscle as regards the relationship between contraction and blood supply. Whereas a striped muscle during contraction becomes hyperæmic, the uterus, the largest mass of unstriped muscle in the body, becomes during contraction relatively anæmic.

It is impossible to pass Dr. Gulland's articles upon the nature and varieties of leucocytes and upon the development of adenoid tissue without bestowing on them not a little adverse criticism, and this, while appreciating fully the long months spent in laborious preparation and examination of tissues, and in studying the literature of the subject, of which they bear ample witness. That Dr. Gulland bases his conclusions upon the view that the leucocytes are symbiotic, and shows at the outset that he totally misconceives the nature of symbiosis, is quite sufficient to render fuller criticism of his views unnecessary. Yet, that it may not be said that I misrepresent his views, it may be as well to quote his words upon this subject:—

> "There are still" (in the Metazoan) "many functions to be performed which can only be discharged by cells possessed of Protozoan characteristics. . . . To perform these functions it is necessary that a certain number of cells should continue to be practically Protozoa, and these cells are what we call 'leucocytes,' so that we may regard them *morphologically as representing those members of the primitive Metazoan colony which escaped differentiation, and have remained unaltered Protozoa through the whole series of Metazoa*" (the italics are mine).

Such inconsequent theorizing goes far to neutralize the minute and careful observations which Dr. Gulland has made into the histology of his subject.

That the formation of bile solids is more closely associated with the general metabolism than with the changes of digestion is the conclusion drawn by Dr. Noël Paton and Mr. Balfour, though somewhat unexpectedly they find that in fever, where the general metabolism is greatly increased and the digestive processes reduced, the amount of bile solids excreted is diminished. All studies of cases of biliary fistula in man are of value, and such full observations as those here described are rare. Of drugs they find calomel and salicylate of soda active in increasing the flow of bile. Whether they are right in looking upon the bile as an excretion, rather than as at the same time a secretion playing an essential part in digestion, is open to doubt. Even if with bile excluded from the intestine only 30 per cent. of the fats ingested pass out unused, that nevertheless is a proportion large enough to demand consideration, and to support the assumption that as a secretion, as well as an excretion, the bile is of definite importance. The ingenious method devised for the estimation of the bile pigments (p. 197) deserves a more extended trial.

At a time when Koch's endeavours to cure tuberculosis by means of injections of products of growth of the tubercle bacilli have brought the whole subject of bacteriotherapeutics prominently to the fore, the full discussion of this by Drs. Woodhead and Wood is very acceptable, based, as it is, upon their own important discovery that the invasion of the organism by the bacillus of anthrax may be prevented by injections of the sterilized fluid in which the *Bacillus pyocyaneus* has been grown. Space forbids that I should do more than indicate that those interested will here find a full account of our present knowledge of a subject which is occupying the energies of every leading bacteriologist.

Of allied interest is the communication by Dr. Wood and Mr. Ross. It has long been known that the advance of erysipelas can often be successfully combated by painting the skin immediately outside the erysipelatous area with some counter-irritant. The authors have studied the *rationale* of this treatment, and conclude that the irritant brings about the formation of a zone of inflammation, with dilatation of the vessels and diapedesis of the white corpuscles, which now, by destroying the micrococci, act as a barrier to the further progress of the disease. With the malignant pustule produced by the inoculation of the anthrax bacilli, similar counter-irritation was effectual in only three out of thirty cases—that is to say, with the more active virus the stimulus applied was not sufficient to produce an effectual barrier.

J. George Adami.

THE CHEMICAL AND BACTERIOLOGICAL EXAMINATION OF POTABLE WATERS.

Examen Químico y Bacteriológico de las Aquas Potables. Por A. E. Salazar y C. Newman, con uno capitulo del Dr. Rafael Blanchard sobre "Los Animales Parásitos introducidos por el Aqua en el Organismo." (London: Burns and Oates, 1890.)

A PECULIAR interest attaches to this work at the present moment in consequence of the sad political events now going on in the country from which it has emanated; for, whilst almost each successive day brings news of the sacrifice of human life in one of the fiercest and most sanguinary civil contests of recent years, the object of this book is to show how the latest results of scientific research may be applied to combating on the same soil some of the ills which flesh is heir to. The publication of this treatise for Chilian students affords the strongest evidence of the rapidity with which scientific knowledge traverses the globe at the present day, and it must be a source of great satisfaction to all interested in the dissemination of the principles of hygiene that there should be a demand for a work of such an advanced character in a country so remote from what we are wont to regard as the centres of civilization.

The scope of this work is more comprehensive than that of perhaps any similar one in our own language; English treatises on water analysis being in general only short manuals giving instructions for the execution of analytical methods devised by their authors, who usually dismiss the rival methods of others with a few words, often not of a very complimentary kind. The pages under review, however, not only give an interesting account of the various methods employed by water-analysts, but subject their several claims to a fair and impartial criticism, whilst detailed information is supplied for carrying out those methods which the authors regard as, on the whole, the most serviceable. Again, a most exhaustive account is given of the bacteriological examination of water, including precise instructions for the cultivation of micro-organisms, the preparation of nutritive media, the sterilization of apparatus, the use of the microscope, and the performance of inoculation experiments on animals. But even this ample programme was inadequate for the ambition of the authors, who have associated with themselves a third colleague, who contributes a bulky appendix on "the animal parasites gaining access to the organism through water." The work is not only profusely illustrated with cuts, but contains also a number of original photographs representing both the microscopic and macroscopic appearance of some bacteria. Indeed, the bacteriological part is the real centre of gravity of the work. A decade will soon have elapsed since the bacteriological examination of waters began to attract much attention in consequence of the ingenious method o gelatin-plate cultivation devised by Koch. It was not, however, until some years later that the method yielded results of any practical importance, inasmuch as it was at first almost exclusively applied by bacteriologists whose previous information on questions of water-supply was of a somewhat limited order, whilst the value of the method for the solution of many hitherto unsolved problems connected with the hygiene of water is even now but imperfectly appreciated by chemists. When the method was first applied to the London water-supply, in the year 1885, it at once brought to light that in the process of sand-filtration, as practised on the large scale, a most astonishing proportion of the micro-organisms present in the unfiltered water were removed, whilst in the best of our deep-well waters the number of microbes found was so small that it seemed probable that the removal of these low forms of life in this process of natural filtration was really complete, and that the few actually found had very likely been imported into the wells from the surface. On the other hand, it was shown that the sand-filters did not wholly remove the organisms present in the unfiltered water, as, in the course of regular examinations carried on over a period of more than three years, a most unmistakable relationship between the number of microbes present in the unfiltered and filtered waters respectively was discernible. The scope of the bacteriological method of examination became very much narrowed when it was discovered that there are many micro-organisms which have the power of multiplying to an enormous extent in the purest waters, including distilled water itself, so that the number of microbes present in a given sample of water affords no indication *per se* of the purity or otherwise of the water. This disturbing element in the bacterioscopic examination of water is not sufficiently emphasized by the authors. But this extraordinary phenomenon of multiplication, although it invalidates the bacteriological process for the general purposes of water examination, does not at all interfere with its successful application to the investigation of the efficiency of filtration, either natural or artificial, provided that the filtered water is subjected to examination without delay after it has undergone the process of filtration.

It should be pointed out that there exists a very widespread misapprehension as to the ideal object of the bacteriological examination of waters, and the authors of this work fall into the same error to some extent also. It is very generally supposed that the main object of a bacteriological examination is to discover whether or not there are disease-producing organisms, *e.g.* those of typhoid, in the water. But this is a point really of very limited importance, and what should be kept in view in an examination of water is the endeavour to discover, not whether the water contains zymotic poison at the time of analysis, but firstly, whether it is exposed to influences which may at any time lead to the introduction of such zymotic poisons, *e.g.* through contamination with sewage;

and secondly, whether, if such organized poisons should gain access, there is any sufficient guarantee or not that they will be destroyed or removed before the water reaches the consumer. It is because the chemical analysis affords us at present a better clue than the bacteriological examination as to whether a water has received sewage or not that it is of more general applicability than the latter; but we must appeal to a bacteriological inquiry in order to ascertain whether, in the event of sewage gaining access to the water, there is a guarantee in the subsequent history of the water that the zymotic poisons, which may at any time accompany the sewage, would undergo removal. In short, the object of nearly all water examinations is obviously to ascertain whether the water may at any time be dangerous to health, and not, even if this could be with certainty determined, whether it contains a zymotic poison at the particular moment of examination. On the other hand, the fact that the microbe, which is now pretty generally accepted as the inducing cause of typhoid fever, has been on more than one occasion actually discovered in drinking-water which was under suspicion of producing an epidemic of that disease, affords most important evidence as to the manner of its distribution.

There is much need of a similar work to this in English, as each year an increasing number of younger medical men are coming forward for the degrees in Public Health which are now granted by several of our Universities, and to these a practical and critical treatise such as this would prove of great value. It is of great importance that such Public Health students should be impressed with a sense of the responsibility which attaches to the examination of waters for domestic purposes, and that most serious mischief may and often does result from such investigations being intrusted to incompetent persons. It is gratifying to see that the authors do not undertake to prescribe any of those artificial standards of purity for drinking-water which so frequently figure in books of this kind, and which are attended with the greatest danger, leading as they do the ignorant to believe that they can pronounce upon the fitness or otherwise of water for drinking purposes from the numbers which they have obtained in a few simple quantitative determinations. For it must never be forgotten that the sanitary examination of water is surrounded with such difficulties that it is only by bringing to bear on each particular case all the evidence that it is possible to obtain, and then interpreting this evidence by the light of an extended experience, that a sound judgment can be arrived at.

P. F. F.

OUR BOOK SHELF.

Botany: a Concise Manual for Students of Medicine and Science. By Alex. Johnstone, F.G.S. (Edinburgh and London: Young J. Pentland, 1891.)

DURING recent years many books on botany have been published, specially for the use of students preparing for examinations. In these a few types and phases of plant life have been described somewhat in detail. In the present case a much wider range has been taken, the result being an illustrated botanical note-book, condensed but not meagre. In the preface the author takes it for granted that every student nowadays attends lectures or demonstrations, and "therefore does not so much require a manual with diffuse explanations, but rather a kind of illustrated digest and general note-book, which will enable him to quickly arrange and make most effective use of the various facts and theories treated of by his teacher." A book on these lines Mr. Johnstone has been successful in producing. It consists of 260 pages and 226 illustrations. Some of the latter are the ones which seem by custom to be considered necessary for reproduction in every fresh botanical manual, while others appear to be new. The outline ones, such as those on p. 30, illustrating the branching of cells, give a much clearer idea than could be done by pages of letterpress. A short introductory chapter points out the position botany holds in science. The strictly botanical part of the work is treated of in four sections, viz. (1) morphology; (2) external morphology or organography; (3) physiology; and (4) taxonomy.

Under morphology, the structure, life-history, contents, and modifications of the cell as an individual are first treated of, after which the combinations of cells to form tissues are described, a special chapter being reserved for the consideration of systems of permanent tissues. The section on external morphology will be found very useful to beginners in systematic botany. It could be wished that the chapter on physiology, although containing much useful information in its 15 pages, had been more extended. The greater part of the remainder of the book is devoted to taxonomy, in which the leading characters of each class (arranged in ascending order) are given, followed by the names of some of the genera, which may be regarded as typical of their respective classes, and interspersed with illustrations. The orders of Angiosperms most frequently met with are represented by short diagnoses and floral diagrams. A useful glossary and index complete the book.

The arrangement throughout the book is good. The various headings, &c., printed in type differing according to their importance, have been very carefully set out, and give a good *résumé* of botany in a tabular form. As an illustrated note-book for a teacher, as well as a student, this work will be found of great use.

C. H. W.

Hand-book of the Ferns of Kaffraria. By T. R. Sim, Curator of the Botanic Garden, King Williamstown, South Africa. 66 pages, 63 plates. (Aberdeen: Taylor and Henderson, 1891.)

THIS little book contains popular descriptions and outline plates of the ferns of Kaffraria, with a chapter of definitions of the botanical terms used in describing ferns, and another giving directions how to cultivate them. The Cape, considering the general interest and remarkable individuality of its phanerogamic flora is very poor in ferns. Kaffraria yields only 68 species, about the same number as Great Britain. Amongst them are two tree ferns, a Cyathea and a Hemitelia, and several herbaceous species of a distinctly subtropical type, such as *Vittaria lineata* and *Marattia fraxinea.* Associated with these are several species with which we are familiar at home, such as *Aspidium aculeatum*, *Cystopteris fragilis*, and *Adiantum Capillus-Veneris.* No doubt by further exploration the list will be considerably increased. The author does not seem to have known anything about the Rev. R. Baur, a Moravian missionary who made large collections of ferns and other plants in Transkeian Kaffraria. The two new species which Mr. Sim claims to have added to the Cape flora cannot be admitted as novelties. *Blechnum remotum* is a variety of the American *B. hastatum*, which I do not think can stand as distinct specifically from the common Cape *B. australe.* The plant figured as *Lomaria lanceolata* on Plate 25 is no doubt *Lomaria inflexa* of Kunze, which was gathered long ago in the colony, by Gueinzius, and is beautifully figured by Kunze from specimens which he forwarded. By the aid of this book there can be no difficulty, even to an amateur, in recognizing any of the Kaffrarian species; and perhaps at some future time Mr. Sim, who was trained at Kew, will extend his area so as to cover the whole colony, for which the total number of ferns known is between 130 and 140.

J. G. BAKER.

Rider Papers on Euclid. Books I.–II. By Rupert Deakin, M.A. (London: Macmillan and Co., 1891.)

THIS little book consists of a series of graduated riders so arranged that the beginner may be able to thoroughly understand and grasp the principal propositions of the first two books of Euclid. One of the chief errors that the author endeavours to avoid is the great stress teachers lay on some of the propositions, which are treated as most important, while others are more or less overlooked.

The method he adopts is to treat each proposition first as a rider, and by giving the enunciation and drawing the figure, see if any of the class can show how it is proved. By this means the subject can be made interesting, as beginners can then look upon each rather as a puzzle than as a stiff piece of work.

The two books are divided into nine parts, each part consisting of six papers, and the riders in each paper, with the exception, of course, of the first, deal with all the preceding propositions. The student is advised in the first six papers only to draw the figures, in order to accustom himself to one of the chief difficulties which, as the author says, "experience shows me that all students feel more or less in solving riders."

At the end are printed the enunciations of the propositions of the two books, followed by several papers set at various examinations. Altogether, teachers will find this an admirable help for classes in which the subject is being treated for the first time.

Die Krystallanalyse oder die chemische Analyse durch Beobachtung der Krystallbildung mit Hülfe des Mikroskops mit theilweiser Benutzung seines Buches über Molekularphysik. Bearbeitet von Dr. O. Lehmann. (Leipzig: Engelmann, 1891.)

WE have so recently noticed at length the splendid work of Dr. O. Lehmann on "Molecular Physics" (see NATURE, vol. xlii. p. 1) that it is only necessary in this place to call attention to this pamphlet of 82 pages, illustrated by 73 woodcuts, in which the author gives the necessary directions for the work of micro-chemical analysis. The instruments used and methods employed are concisely stated, and all the essential details of the operations are supplied to the chemist in this little handbook. Dr. Lehmann claims, not unjustly, that the methods of micro-chemical analysis must play the same part in the laboratory of the organic chemist as spectral analysis does in the laboratory of the inorganic chemist.

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 University of London.

MY friend, Mr. Thiselton Dyer, invites me, by his references to what I have written on this subject, to a discussion in your columns. I am very unwilling to accept the invitation, because I have already and often stated my views, and because I see by the length of Mr. Dyer's letter that I may be led into an interminable labyrinth of side-issues. The official report in which are published the minutes of the evidence given before the Royal Commission which sat on this subject in the year 1888, contains a more lengthy discussion of the subject by myself and others than it is possible to carry through in the columns of NATURE; and I could wish that for once those interested in a subject would rescue from proverbial oblivion the pages of careful statement entombed in a Blue-book. Since, however, my friend trails his coat, it would be doing violence to my old-established regard for him to refuse to tread on it—just a little.

The question raised by Mr. Dyer seems to be, why should not the examining board in Burlington Gardens undergo certain reforms and continue to be the so-called University of London? It has done good service to education, he says, and with the removal of more than half its members and their replacement by gentlemen who either really know or really care about University education it might do more. If it were, he suggests, to rise superior to all its most solemn obligations and falsify the pledges of its founders by undertaking to teach as well as to examine, it would really be as much of a "teaching University" as is either Oxford or Cambridge, and its non-collegiate supporters from all parts of Britain might enjoy the spectacle of the mother-college (University College) from which this examining board took birth, abandoning in favour of Burlington Gardens those traditions of scientific research which have made the College in some measure a realization of Fichte's ideal.

[Mr. Dyer seems to have forgotten the facts when he contends that such teaching as Fichte sketched in his plan for the University of Berlin, cannot be carried on in the same institution or by the same men who administer the teaching required by a University student at the commencement of his career. Fichte's plan was carried out in the University of Berlin, and has been followed by every other University in Germany. The very questions which we are now debating were debated in the early years of this century in Germany, and the Jesuits' plan of education by examination was rejected. University College was founded (except so far as it was a private enterprise) on the lines of a German University, and only required the *prestige* and independence conferred by the power of granting University degrees to enable it to fulfil in London Fichte's ideal. Its professors have never been (as Mr. Dyer well knows) mere instructors for examination purposes. The researches of Graham, Williamson, Sharpey, and of Michael Foster, Sanderson, Schäfer, Kennedy, and many others have been carried on in its laboratories. The proposal to detach such work from the London Colleges, and to associate it with the examining board in Burlington Gardens, on the ground that it is inconsistent with the teaching of University undergraduates, appears to me to involve an erroneous conception of what University education and University organization should be. This by way of parenthesis.]

The point which I wish to insist on is that, excepting the proposal to undertake higher professorial teaching, I have no objection whatever to the reforms of the examining body in Burlington Gardens advocated by Mr. Dyer.

What I desire (and I merely use the first person singular for the purpose of discussion, and not because I stand alone in my wishes, or undervalue the support of others) is that, without any interference with the Burlington Gardens board, the privilege of granting degrees should be conferred by the Crown upon a combined Senate consisting of the Professors of University and King's Colleges (the authority of the councils of the two Colleges being duly guarded).

The fact that Burlington Gardens are in London and that University and King's College are also in London, as well as the talk about a teaching University "in and for" London, have very little bearing upon the question as to whether it is or is not desirable to grant University privileges to the two Colleges. There is population enough and accommodation enough for a dozen Universities within the metropolitan area. As far as I am able to judge as to the principles which should guide the Crown in bestowing the privilege of incorporation as a University, the only questions to be asked are: "Does the body which asks for this privilege consist of learned men whose work will be facilitated by the granting to them of this ancient and honourable position? Do they give guarantees of material support, and of a public demand for their teaching, which will enable them to discharge the functions of a University with dignity and efficiency, now and hereafter? Will the concession to them of this privilege tend directly or indirectly or both to the public welfare?" I cannot imagine that anyone will undertake to give a negative response to these questions in reference to the combined Colleges, University and King's. Certain it is that during the acute discussion which has been carried on for the last four or five years, no one has ventured to do so. What has happened is simply this, that persons connected with Burlington Gardens have opposed the bestowal of University powers on the two Colleges, either for the reason that they consider the withdrawal of the Colleges from the sphere of the operations of the Burlington Gardens examining board a reflection upon that body, or because they are unwilling that a privilege should be conceded to Colleges, however well fitted to receive it, which their own local or provincial college is not yet important enough to claim. A further incident of the movement has been that the just demands of London medical students and their teachers for a University degree in medicine, as readily attainable by London students as are the medical degrees of Edinburgh, Glasgow, Dublin, Aberdeen, St. Andrews, Durham, and Cambridge, by the students of those places, have been formulated and generally approved.

Neither of these accompaniments of the request for University powers made by University and King's Colleges seems to me to touch the question as to whether it is right on grounds of public policy to accede to that request. Sir William Thomson, Sir George Stokes, and Mr. Weldon after an exhaustive inquiry were in favour of granting the privilege asked for. Three lawyers, namely Lord Selborne, Sir James Hannen, and Sir James Ball, were not persuaded. The commission composed of these six gentlemen agreed to ask the Burlington Gardens authorities to try to devise such alterations in their "University" as would satisfy the aspirations of University and King's Colleges. Burlington Gardens has absolutely and hopelessly failed in this attempt—as anyone conversant with the conditions of the problem could foresee must be the case. They have proposed a scheme which has not been accepted by the Colleges, and has also been rejected by their own provincial graduates. Why should more time be wasted about the attempt to put three pints into a quart bottle? Let the Burlington Gardens University continue to exercise its function of examining for schools and colleges which are not strong enough to examine for themselves, and let them continue so to do only until the colleges are fit to receive independent University powers; let the Senate reform itself if it can, and if the absurd dead-weight of graduates tied round its neck and called Convocation will permit it to do so. But do let us have in the meanwhile a genuine professorial University set on foot in London, not because it is London, but because University and King's Colleges are there, and respectfully petition Her Majesty to do for them what the monarch has done (not unwisely, it must be allowed) in past days for the Senatus Academicus of Edinburgh, of Aberdeen, of Leyden, of Berlin, Bonn, Leipzig, and other cities.

What the two Colleges ask for is a privilege—a special favour. To include other institutions as co-recipients of the privilege would destroy its character and its value. As Mr. Dyer points out, we do not want a federal University, such as are Cambridge and Oxford and the Victoria. We have seen enough of the friction and never-ending committees and schedules of such clumsily organized Universities. By limiting the charter to University and King's Colleges, a professorial University can be established in which the professors shall be—as in the Scotch and the German Universities—at once the teachers, the examiners, and the governing body. I cannot perceive what good can be attained by joining a series of rival teaching bodies together, calling them a University, and setting them to waste the lives of their lecturers in committees and boards and the drawing up of schedules. The only persons who gain by such wasteful arrangements are the busybodies and bureaucrats, who either acquire importance by their intermediation in the disputes of rival teachers, or gain a livelihood by pompously conducting the affairs of the committees and boards in which what is good and strong in each member is counteracted, whilst only what is feeble, worthless, and emasculate survives.

The professorial University formed by a union of King's and University would be of modest dimensions, and rightly so. It would in virtue of its charter be able to grow. This I regard as the most important feature in the proposal. Instead of hastily bringing together a variety of teaching bodies, we should leave it to the new University to assimilate them, make terms with them, in the course of time.

Though they are modest bodies compared with the Imperial centralizing institution, from the thraldom of which they seek to escape, yet King's and University Colleges can show figures stating the property and the number of students which they would bring to the new University, which are far larger than the corresponding figures for many other Universities both in the United Kingdom and abroad. Their buildings and land are worth half a million sterling. Their annual receipts exceed £30,000; their annual attendance of students is as great as that of the University of Oxford. This is an ample basis; with this start the new University would without any doubt be able to ensure a steady growth, increase of its property and of its teaching capacities, by a healthy and gradual development.

Mr. Dyer skilfully seeks to enlist support for the supremacy of Burlington Gardens by asking the following questions (to which he does not give the answers for obvious reasons): "Why should two out of many institutions be picked out for University honours? Why should Bedford College be left out? How can the Royal College of Science be ignored? Why ignore the City and Guilds Institute?"

These questions are excusable only when we admit that Mr. Dyer may for the nonce treat his defence of Burlington Gardens as a lawyer may treat a shady case entrusted to his advocacy in the courts.

The reason why the Crown should pick out the two Colleges for the University privilege is, firstly, that they and they alone have asked for it; secondly, that they and they alone possess the property, professoriate, status, and historical purpose which could warrant the privilege; and, lastly, that University powers are essentially a privilege fitted and intended to strengthen and build up the institution to which they are granted above others. Bedford College is cited by Mr. Dyer solely, I am afraid, with the purpose of rousing the jealousy of its members. They are, I hope and believe, too sensible to be led to imagine that their excellent institution is at all comparable in magnitude or importance to University and King's. As to the Royal College of Science, the answer is different. It is a Government institution under a special department founded and carried on with a special purpose. It grants its own certificates and fulfils its objects. I see no objection to its receiving the privilege of granting those certificates in the form of University degrees; but it could not be associated with University and King's Colleges to form one Senatus Academicus. To introduce it or the City and Guilds Institute into the new University would necessitate the formation of what I am persuaded would be a pernicious and futile organization—namely, a federal University. And, moreover, it appears that both the Royal College or Normal School of Science and the Guilds Institute were founded with public money and are carried on for other purposes than that of training University students, and that their managers do not seek the privilege of granting University degrees nor consider that their public utility would be increased by any such federation with the new University as Mr. Dyer suggests. There is plenty of room in London for non-University Colleges as well as for more than one University. The objectionable notion which Mr. Dyer and some others entertain is that these institutions can be made more useful by arbitrarily bringing them under the control of some central government—such as is now exercised by Burlington Gardens.

The fact appears to me to be that centralization in University matters is wasteful of time and energy, paralyzing and delusive. Two Colleges like University and King's can unite and settle their affairs together, and if granted such powers as other Universities possess they may in time take into their organization, partially or completely, other institutions, or arrange methods of co-operation with other institutions. Indeed they would, if incorporated as a University, be sure to do this, and to do it far more efficiently than could be the case were they abruptly associated with a variety of rival corporations, each with equal rights and equal voice, and left to compromise and to vote through endless committees, either as constituents of a reformed Burlington Gardens University or of a new piece of federal futility.

Mr. Dyer has wisely avoided the question of the demand for medical degrees. I confess that this is a very difficult problem on account of the attitude of the medical profession. If the medical profession is to be allowed to grant medical degrees, the present significance and a good deal of the value of the University privilege will be destroyed. It is, I believe, quite useless to attempt to *satisfy* the demands of the medical profession in this matter. The thing to be aimed at is to remedy an injustice; it is necessary to provide a degree as accessible as that of other Universities through whatever University or Universities may exist, hereafter, in London.

In my evidence to the Commissioners I made some suggestions on this matter. I am inclined to think that the following steps are necessary for a satisfactory solution of the problem: (*a*) the abolition of the medical faculties of University and

King's Colleges—excepting the Professorships of Anatomy, Physiology, Pathology, and Forensic Medicine—and the creation of independent clinical schools attached to the North London and Lincoln's Inn Hospitals; (*b*) the nomination of a medical professoriate for the new University by representatives of all the London medical schools, vacancies to be hereafter filled up on the recommendation of the Senate of the University; (*c*) the recognition, under conditions, by the new University, of the clinical teaching in each of the London hospitals, and the admission of students to its medical degrees on condition of having passed the prescribed examinations of the University and of having pursued not necessarily more than one-half of the entire curriculum under the professors of the University. The University might also be required to recognize (in exchange for a like concession) the examinations in certain subjects of the Conjoint Board as excusing candidates from like examination by the University.

This is undeniably a complex part of the subject. It would be simplest, and probably satisfactory in the end, to grant the power of giving medical degrees to the limited body (King's and University) and to leave it to make such arrangements as it might find expedient with the medical schools of London. The professional feeling of the medical faculties of University and King's Colleges would insure their making an equitable use of the privilege, such as their medical brethren would heartily approve. E. Ray Lankester.

P.S.—There is one argument put forward by Mr. Dyer which I have omitted to notice in the foregoing, but should like to tread on. He quotes my opinion that the University may usefully examine scholars passing from the schools to the University as a test both of the work of the schoolboy and of the efficiency of the schoolmaster, and proceeds to maintain that in the same way an examining board may usefully check not only the work of University undergraduates, but of their teachers. This is advanced as an argument in favour of external or superior examining boards in University examinations as opposed to examinations conducted by University professors with associated external examiners. Mr. Dyer has, however, omitted to cite the reply which I had already given to his specious argument. It is this: the University is the highest term in the educational hierarchy. It may fittingly examine students who are about to pass from the school to continue their studies on a higher level, viz. its own. But who or what are the persons recognized as standing above the University professoriates? I do not know of any such body. It is precisely the arrogation of this position for the Senate of the University of London which renders it objectionable. There is necessarily a limit to the organization of authority in educational matters, and it is as absurd for the members of a central examining board to control the teaching of those who are *ex hypothesi* the most capable teachers in the country as it is for the Home Office to control the details of the work of the Senate of Burlington Gardens. Either University professors are worthy to occupy their positions or they are not—no higher branch of the educational profession exists. To coerce them by means of Senates composed of retired teachers and *dilettanti* educationists is clearly injurious: to set them to work to criticize and worry one another as "impartial examiners" is odious and a waste of their time. The only thing to do is to take such measures as are possible for insuring that no one who is not fit for the position shall hold office as a professor in a chartered University, and to so arrange that it shall be to the interest of the professor, and also to that of his University, for him to discharge his duties efficiently.

If we are to have an indefinite series of authorities one above the other, who, one would like to know, is to control the examining board which sits over the professors? And who again to control these controllers?

The bureaucratic machinery which seems to find favour with Mr. Dyer is, in my opinion, superfluous. The most efficient Universities (in two differing directions), those of Germany and of Scotland, have no authority in educational matters above that of the professoriate, and are not subject, like Oxford, Cambridge, and London, to the interference of graduates in the form of convocation.

Mr. Thiselton Dyer appears to think that Fichte's ideal of a University is unrealizable, unless, as he supposes, "some wealthy man gives, say, half a million to found such a University in some quiet country town in England, where professor and pupils might labour together, undisturbed by the life and movement of a big city, or the worry of the examination-room, for the advantage of knowledge." I venture to think that this supposition of Mr. Thiselton Dyer's conveys the unwelcome truth that the conception of the true nature of a University has not yet reached some even of that section of the British public who have earned well-merited distinction in science; and it is as one who has had experience of a Scottish and a German University, in the character of student and teacher, and of two English University Colleges as teacher, that I ask permission as shortly as I can to place before your readers what many minds aim at, in the hope that a teaching University in London, call it what you will, would ultimately provide it.

I reiterate the assertion which I lately made in a letter to the *Times*, that a University is primarily a place for the extension of the bounds of knowledge; this is to be achieved by the labours of the professors and teaching staff; by fellows, specially appointed for that purpose, if the system of fellowships is thought desirable, although, in my opinion and experience, much may be said against it; and by the *whole body of the students*. Of course it is not to be supposed that every student is capable of discovering new facts or of applying principles in an original manner; but almost every man is endowed with some share of inventive faculty, which must ultimately be developed, if he is to make his way in the world otherwise than as a day-labourer, or as a piece-worker in a factory, or as a copying-clerk; and the object of a University should be to cultivate this faculty to the utmost. An efficient medical man spends his life in clinical experimentation; a successful barrister exercises his ingenuity in applying old decisions to new cases; a competent engineer not merely studies how to improve his machinery, but also studies his fellow-creatures, and the chances of trade, so as to bring his manufactures into new fields. If the inventive faculty is not developed at the University, it will be developed later, in every man who fulfils his duty to his fellow-creatures and to himself.

Now I dare to contend that the degree-stamp of the English Universities, especially of the University of London, except in certain cases in its highest degrees, such as the D.Mus., D.Litt., M.D., and D.Sc. degrees (and these only as a result of recent modifications), is of no value whatever in the eyes of that portion of the public whose opinion carries with it a commercial reward. Speaking for myself, I have had assistants, graduates of Edinburgh, of London, and of German Universities, and I unhesitatingly state that the only degrees to which I should attach the least importance are those of Germany, and that because there is in them some evidence that the graduate has had at least an initiation into the methods of research. As this assertion may be applied personally, I should wish it to be clearly understood that I have no reason whatever to be in any way dissatisfied with graduates from Edinburgh or from London, but merely to state that the fact of their being graduates in no way influenced me in their appointment. And many manufacturers, in want of assistants, actually regard an English degree in the light of a disqualification; so that most of the posts of "works-chemists" are held by non-graduates. They prefer, in fact, to train their own men—that is, to give them such an education in research as bears on the particular problems which they themselves have to solve; or to take them from the laboratories of general analysts, where new problems present themselves from time to time.

It is impossible, under existing circumstances, to give undergraduates such training. They have examination on the brain. They judge from the standpoint of "Will this 'pay' at an examination?" not from the standpoint of "Is this worth knowing?" And they cannot be blamed. It is not the fault of the examiners; it is not the fault of the students; the professors, I believe, do not, except in a general way, follow the syllabuses; it is simply that the better students conscientiously aim at what is set before them—a degree that has no market value, except in the eyes of school teachers. Personally I cannot complain that I do not get research done by students; in actual fact a considerable number do stay after graduation, and some do not graduate at all; I merely hold the opinion that the method is on wholly wrong lines; that a degree, if given, should be the official testimony to a certain time spent with diligence and profit in gaining knowledge of how to attack problems—of how to acquire knowledge useful for the purpose in view.

It will be said that honours-degrees will find no place in such a system. Why should they? Does the desire to beat competitors stimulate a desire for knowledge? Does it stimulate originality? I for one would willingly see them non-existent.

Up to a certain point, the acquisition of knowledge of facts should be, as at present, tested by examination; but I am convinced that the system is at present pushed to an extreme, and that much better results would be gained by giving a degree for training, and that can be done only by the trainer—the teacher. He will, as a rule, be glad to share his responsibility with, and to benefit by the advice of, an outsider; but with him should ultimately rest the decision as to the merit or demerit of a candidate, as he is the only person able to judge. Under such a system, there would be little plucking; for the student would be advised not to present himself, unless he had sufficiently qualified.

It may also be said that undue advantage would be taken by the teacher in recommending unfit students for graduation. Teachers in such positions are, I believe, generally honourable men; they are chosen after the most careful inquiry into their past career. It is not held fitting in commercial circles to appoint a clerk or an accountant on good recommendations, and after sufficient apprenticeship, and then to surround him with safeguards, in case he turn out incapable or dishonest.

The objection may possibly be raised, that under such a system the standard of degrees would be very uneven; but what of that? As at present, anyone applying for a post of any kind would furnish a reference to his teachers; and a private letter from one well acquainted with the candidate turns the scale, for or against, in spite of every degree in the United Kingdom.

In plain English, degrees, as at present given, are not valued by that portion of the public qualified to judge; and we must face this fact, and endeavour to render a degree a real mark of merit.

I believe, with Mr. Dickins, that the examinations of the University of London have done much in disseminating knowledge, and they have therefore proved of great service, but except in the case of the higher degrees before mentioned, and of the degrees in the Faculty of Medicine where evidence of training is a *sine quâ non*, I greatly doubt whether they have contributed towards the creation of knowledge, or training in originality. And from the very nature of the constitution of the University of London, it is impossible that it should be otherwise. This very morning, I happened to ask a student attending my lectures on organic chemistry why he, a B.Sc. in chemistry, was attending my lectures. His reply was characteristic. "I scamped up enough of the subject privately, sir, to squeeze through; but now I wish to know it." In any right system, such a proceeding should be impossible.

It is therefore with the hope that the creation of a teaching University for London might tend to remedy such evils, that I, for one, would welcome it. I would urge that the distinguished names mentioned by Mr. Thiselton Dyer are surely guarantees that the London Colleges recently possessed men capable of imparting the highest standard of knowledge, and of stimulating true originality; yet I believe that it is by no means "cutting cheese with a razor" to employ just such men in watching over the development even of junior students; and it is not without advantage to the most able men of science and of letters to be obliged periodically to devote consideration to "elements" and to pass in review first principles. It counteracts the tendency towards specialization, which, however valuable, always limits the mental horizon. I will undertake to say that the quality of the most advanced teaching in biology and physiology in University College when the chairs were occupied by Burdon Sanderson, by Michael Foster, and by Lankester knew no limit; and I greatly doubt the wisdom of appointing teachers whose attention is to be devoted exclusively to research. As my predecessor, Prof. Williamson, often remarked, it is more difficult to teach junior than to teach senior students; and while the superintendence of exercise and laboratory work may well be shared by assistants, in order that the professor may have time to devote to research, and to superintendence of advanced students, it would be a serious calamity were the influence of such minds to be withdrawn wholly from the juniors.

It is precisely by such a federation of Colleges such as University and King's, and of other sufficiently qualified institutions which have the will and the power to join, that specialization may ultimately be effected. The future occupants of the chairs may be chosen so as to represent every side of a subject; and anyone wishing to pursue research in any special branch would have no difficulty in selecting that particular college where his specialty was also the specialty of the teacher.

WILLIAM RAMSAY.

No well-wisher of the University can feel otherwise than grateful to you for affording a portion of your valuable space for the letters of Mr. Thiselton Dyer and Mr. Dickins on this subject. No two men could be found to speak with greater authority from first-hand knowledge of the facts. The arguments on the subject have been too much of an *ex parte* character hitherto, not seldom based on insufficient information or erroneous impressions. Nothing, for example, could be further from the truth than the statement in the *Times* of May 13, by the writer of what was upon the whole a fair and comprehensive leading article, that "there is no reason why the highest honours of the University of London should not be obtained by a person who never set foot in London or even in England." Many, who like myself voted for the projected scheme of the Senate, must have felt, as I did, as a result of a wide and varied educational experience, that it was potential with great good in the future, and could be accepted as the working basis of the future development of the University, although we felt that the one serious blot in it was the abandonment of uniformity in the examinations for the pass degrees. I verily believe that this was the one thing fatal to its success in Convocation; that it was so far in excess of the recommendations of the Royal Commission as to be unwarrantable; and that it put a lever into the hands of the opposition, of which—as the event proved—a practised disputant like Mr. Bompas did not fail to make most effective and disastrous use.

Wellington College, Berks, May 25. A. IRVING.

Quaternions and the "Ausdehnungslehre."

THE year 1844 is memorable in the annals of mathematics on account of the first appearance on the printed page of Hamilton's "Quaternions" and Grassmann's "Ausdehnungslehre." The former appeared in the July, October, and supplementary numbers of the *Philosophical Magazine*, after a previous communication to the Royal Irish Academy, November 13, 1843. This communication was indeed announced to the Council of the Academy four weeks earlier, on the very day of Hamilton's discovery of quaternions, as we learn from one of his letters. The author of the "Ausdehnungslehre," although not unconscious of the value of his ideas, seems to have been in no haste to place himself on record, and published nothing until he was able to give the world the most characteristic and fundamental part of his system with considerable development in a treatise of more than 300 pages, which appeared in August 1844.

The doctrine of quaternions has won a conspicuous place among the various branches of mathematics, but the nature and scope of the "Ausdehnungslehre," and its relation to quaternions, seem to be still the subject of serious misapprehension in quarters where we naturally look for accurate information. Historical justice, and the interests of mathematical science, seem to require that the allusions to the "Ausdehnungslehre" in the article on "Quaternions," in the last edition of the "Encyclopædia Britannica," and in the third edition of Prof. Tait's "Treatise on Quaternions," should not be allowed to pass without protest.

It is principally as systems of geometrical algebra that quaternions and the "Ausdehnungslehre" come into comparison. To appreciate the relations of the two systems, I do not see how we can proceed better than if we ask first what they have in common, then what either system possesses which is peculiar to itself. The relative extent and importance of the three fields, that which is common to the two systems, and those which are peculiar to each, will determine the relative rank of the geometrical algebras. Questions of priority can only relate to the field common to both, and will be much simplified by having the limits of that field clearly drawn.

Geometrical addition in three dimensions is common to the two systems, and seems to have been discovered independently both by Hamilton and Grassmann, as well as by several other persons about the same time. It is not probable that any especial claim for priority with respect to this principle will be urged for either of the two with which we are now concerned.

The functions of two vectors which are represented in quaternions by $S\alpha\beta$ and $V\alpha\beta$ are common to both systems as published in 1844, but the quaternion is peculiar to Hamilton's. The linear vector function is common to both systems as ultimately developed, although mentioned only by Grassmann as early as 1844.

To those already acquainted with quaternions, the first question will naturally be: To what extent are the geometrical methods which are usually called quaternionic peculiar to Hamilton, and to what extent are they common to Grassmann? This is a question which anyone can easily decide for himself. It is only necessary to run one's eye over the equations used by quaternionic writers in the discussion of geometrical or physical subjects, and see how far they necessarily involve the idea of the quaternion, and how far they would be intelligible to one understanding the functions $S\alpha\beta$ and $V\alpha\beta$, but having no conception of the quaternion $\alpha\beta$, or at least could be made so by trifling changes of notation, as by writing S or V in places where they would not affect the value of the expressions. For such a test the examples and illustrations in treatises on quaternions would be manifestly inappropriate, so far as they are chosen to illustrate quaternionic principles, since the object may influence the form of presentation. But we may use any discussion of geometrical or physical subjects, where the writer is free to choose the form most suitable to the subject. I myself have used the chapters and sections in Prof. Tait's "Quaternions" on the following subjects: Geometry of the straight line and plane, the sphere and cyclic cone, surfaces of the second degree, geometry of curves and surfaces, kinematics, statics and kinetics of a rigid system, special kinetic problems, geometrical and physical optics, electrodynamics, general expressions for the action between linear elements, application of ∇ to certain physical analogies, pp. 160–371, except the examples (not worked out) at the close of the chapters.

Such an examination will show that for the most part the methods of representing spatial relations used by quaternionic writers are common to the systems of Hamilton and Grassmann. To an extent comparatively limited, cases will be found in which the quaternionic idea forms an essential element in the signification of the equations.

The question will then arise with respect to the comparatively limited field which is the peculiar property of Hamilton, How important are the advantages to be gained by the use of the quaternion? This question, unlike the preceding, is one into which a personal equation will necessarily enter. Everyone will naturally prefer the methods with which he is most familiar; but I think that it may be safely affirmed that in the majority of cases in this field the advantage derived from the use of the quaternion is either doubtful or very trifling. There remains a residuum of cases in which a substantial advantage is gained by the use of the quaternionic method. Such cases, however, so far as my own observation and experience extend, are very exceptional. If a more extended and careful inquiry should show that they are ten times as numerous as I have found them, they would still be exceptional.

We have now to inquire what we find in the "Ausdehnungslehre" in the way of a geometrical algebra, that is wanting in quaternions. In addition to an algebra of vectors, the "Ausdehnungslehre" affords a system of geometrical algebra in which the point is the fundamental element, and which for convenience I shall call Grassmann's algebra of points. In this algebra we have first the addition of points, or quantities located at points, which may be explained as follows. The equation

$$aA + bB + cC + \&c. = eE + fF + \&c.,$$

in which the capitals denote points, and the small letters scalars (or ordinary algebraic quantities), signifies that

$$a + b + c + \&c. = e + f + \&c.,$$

and also that the centre of gravity of the weights a, b, c, &c., at the points A, B, C, &c., is the same as that of the weights e, f, &c., at the points E, F, &c. (It will be understood that negative weights are allowed as well as positive.) The equation is thus equivalent to four equations of ordinary algebra. In this Grassmann was anticipated by Möbius ("Barycentrischer Calcul," 1827).

We have next the addition of finite straight lines, or quantities located in straight lines (*Liniengrössen*). The meaning of the equation

$$AB + CD + \&c. = EF + GH + \&c.$$

will perhaps be understood most readily, if we suppose that each member represents a system of forces acting on a rigid body. The equation then signifies that the two systems are equivalent. An equation of this form is therefore equivalent to six ordinary equations. It will be observed that the *Liniengrössen* AB and CD are not simply vectors; they have not merely length and direction, but they are also located each in a given line, although their position within those lines is immaterial. In Clifford's terminology, AB is a *rotor*, AB + CD a *motor*. In the language of Prof. Ball's "Theory of Screws," AB + CD represents either a *twist* or a *wrench*.

We have next the addition of plane surfaces (*Plangrössen*). The equation

$$ABC + DEF + GHI = JKL$$

signifies that the plane JKL passes through the point common to the planes ABC, DEF, and GHI, and that the projection by parallel lines of the triangle JKL on any plane is equal to the sum of the projections of ABC, DEF, and GHI on the same plane, the areas being taken positively or negatively according to the cyclic order of the projected points. This makes the equation equivalent to four ordinary equations.

Finally, we have the addition of volumes, as in the equation

$$ABCD + EFGH = IJKL,$$

where there is nothing peculiar, except that each term represents the six-fold volume of the tetrahedron, and is to be taken positively or negatively according to the relative position of the points.

We have also multiplications as follows:—The line (*Liniengrösse*) AB is regarded as the product of the points A and B. The *Plangrösse* ABC, which represents the double area of the triangle, is regarded as the product of the three points A, B, and C, or as the product of the line AB and the point C, or of BC and A, or indeed of BA and C. The volume ABCD, which represents six times the tetrahedron, is regarded as the product of the points A, B, C, and D, or as the product of the point A and the *Plangrösse* BCD, or as the product of the lines AB and BC, &c.

This does not exhaust the wealth of multiplicative relations which Grassmann has found in the very elements of geometry. The following products are called *regressive*, as distinguished from the *progressive*, which have been described. The product of the *Plangrössen* ABC and DEF is a part of the line in which the planes ABC and DEF intersect, which is equal in numerical value to the product of the double areas of the triangles ABC and DEF multiplied by the sine of the angle made by the planes. The product of the *Liniengrösse* AB and the *Plangrösse* CDE is the point of intersection of the line and the plane with a numerical coefficient representing the product of the length of the line and the double area of the triangle multiplied by the sine of the angle made by the line and the plane. The product of three *Plangrössen* is consequently the point common to the three planes with a certain numerical coefficient. In plane geometry we have a regressive product of two *Liniengrösse*, which gives the point of intersection of the lines with a certain numerical coefficient.

The fundamental operations relating to the point, line, and plane are thus translated into analysis by multiplications. The immense flexibility and power of such an analysis will be appreciated by anyone who considers what generalized multiplication in connection with additive relations has done in other fields, as in quaternions, or in the theory of matrices, or in the algebra of logic. For a single example, if we multiply the equation

$$AB + CD + \&c. = EF + GH + \&c.$$

by PQ (P and Q being any two points), we have

$$ABPQ + CDPQ + \&c. = EFPQ + GHPQ + \&c.,$$

which will be recognized as expressing an important theorem of statics.

The field in which Grassmann's algebra of points, as distinguished from his algebra of vectors, finds its especial application and utility, is nearly coincident with that in which, when we use the methods of ordinary algebra, tetrahedral or anharmonic co-ordinates are more appropriate than rectilinear. In fact, Grassmann's algebra of points may be regarded as the application of the methods of multiple algebra to the notions connected with tetrahedral co-ordinates, just as his or Hamilton's algebra of vectors may be regarded as the application of the methods of multiple algebra to the notions connected with rectilinear co-ordinates. These methods, however, enrich the field to which they are applied with new notions. Thus the notion of the co-ordinates of a line in space, subsequently introduced by Plücker, was first given in the "Ausdehnungslehre" of 1844. It should also be observed that the utility of a multiple algebra, when it takes the place of an ordinary algebra of four co-ordinates, is very much greater than when it takes the place of three co-ordinates, for the same reason that a multiple algebra taking the place of three co-ordinates is very much more useful than one taking the place of two. Grassmann's algebra of points will always command the admiration of geometers and analysts, and furnishes an instrument of marvellous power to the former, and in its general form, as applicable to space of any number of dimensions, to the latter. To the physicist an algebra of points is by no means so indispensable an instrument as an algebra of vectors.

Grassmann's algebra of vectors, which we have described as coincident with a part of Hamilton's system, is not really anything separate from his algebra of points, but constitutes a part of it, the vector arising when one point is subtracted from another. Yet it constitutes a whole, complete in itself, and we may separate it from the larger system to facilitate comparison with the methods of Hamilton.

We have, then, as geometrical algebras published in 1844, an algebra of vectors common to Hamilton and Grassmann, augmented on Hamilton's side by the quaternion, and on Grassmann's by his algebra of points. This statement should be made with the reservation that the *addition* both of vectors and of points had been given by earlier writers.

In both systems as finally developed we have the linear vector function, the theory of which is identical with that of strains and rotations. In Hamilton's system we have also the linear quaternion function, and in Grassmann's the linear function applied to the quantities of his algebra of points. This application given those transformations in which projective properties are preserved, the doctrine of reciprocal figures or principle of duality, &c. (Grassmann's theory of the linear function is, indeed, broader than this, being co-extensive with the theory of matrices; but we are here considering only the geometrical side of the theory.)

In his earliest writings on quaternions, Hamilton does not discuss the linear function. In his "Lectures on Quaternions" (1853), he treats of the inversion of the linear vector function, as also of the linear quaternion function, and shows how to find the latent roots of the vector function, with the corresponding axes for the case of real and unequal roots. He also gives a remarkable equation, *the symbolic cubic*, which the functional symbol must satisfy. This equation is a particular case of that which is given in Prof. Cayley's classical "Memoir on the Theory of Matrices" (1858), and which is called by Prof. Sylvester the Hamilton-Cayley equation. In his "Elements of Quaternions" (1866), Hamilton extends the symbolic equation to the quaternion function.

In Grassmann, although the linear function is mentioned in the first "Ausdehnungslehre," we do not find so full a discussion of the subject until the second "Ausdehnungslehre" (1862), where he discusses the latent roots and axes, or what corresponds to axes in the general theory, the whole discussion relating to matrices of any order. The more difficult cases are included, as that of a strain in which all the roots are real, but there is only one axis or unchanged direction. On the formal side he shows how a linear function may be represented by a quotient or sum of quotients, and by a sum of products, *Lückenausdruck*.

More important, perhaps, than the question when this or that theorem was first published is the question where we first find those notions and notations which give the key to the algebra of linear functions, or the algebra of matrices, as it is now generally called. In vol. xxxi. p. 35, of this journal, Prof. Sylvester speaks of Cayley's "ever-memorable" "Memoir on Matrices" as constituting "a second birth of Algebra, its *avatar* in a new and glorified form," and refers to a passage in his "Lectures on Universal Algebra" from which, I think, we are justified in inferring that this characterization of the memoir is largely due to the fact that it is there shown how matrices may be treated as extensive quantities, capable of addition as well as of multiplication. This idea, however, is older than the memoir of 1858. The *Lückenausdruck*, by which the matrix is expressed as a sum of a kind of products (*lückenhaltig*, or open), is described in a note at the end of the first "Ausdehnungslehre." There we have the matrix given not only as a sum, but as a sum of products, introducing a multiplicative relation entirely different from the ordinary multiplication of matrices, and hardly less fruitful, but not lying nearly so near the surface as the relations to which Prof. Sylvester refers. The key to the theory of matrices is certainly given in the first "Ausdehnungslehre," and if we call the birth of matricular analysis the second birth of algebra, we can give no later date to this event than the memorable year of 1844.

The immediate occasion of this communication is the following passage in the preface to the third edition of Prof. Tait's "Quaternions":—

"Hamilton not only published his theory complete, the year before the first (and extremely imperfect) sketch of the 'Ausdehnungslehre' appeared; but had given ten years before, in his protracted study of Sets, the very processes of external and internal multiplication (corresponding to the Vector and Scalar parts of a product of two vectors) which have been put forward as specially the property of Grassmann."

For additional information we are referred to art. "Quaternions," "Encyc. Brit.," where we read respecting the first "Ausdehnungslehre":—

"In particular two species of multiplication ('inner' and 'outer') of directed lines in one plane were given. The results of these two kinds of multiplication correspond respectively to the numerical and the directed parts of Hamilton's quaternion product. But Grassmann distinctly states in his preface that he had not had leisure to extend his method to angles in space. . . . . But his claims, however great they may be, can in no way conflict with those of Hamilton, whose mode of multiplying *couples* (in which the 'inner' and 'outer' multiplication are essentially involved) was produced in 1833, and whose quaternion system was completed and published before Grassmann had elaborated for press even the rudimentary portions of his own system, in which the veritable difficulty of the whole subject, the application to angles in space, had not even been attacked."

I shall leave the reader to judge of the accuracy of the general terms used in these passages in comparing the first "Ausdehnungslehre" with Hamilton's system as published in 1843 or 1844. The specific statements respecting Hamilton and Grassmann require an answer.

It must be Hamilton's "Theory of Conjugate Functions or Algebraic Couples" (read to the Royal Irish Academy 1833 and 1835, and published in vol. xvii. of the Transactions), to which reference is made in the statements concerning his "protracted study of Sets" and "mode of multiplying *couples*." But I cannot find anything like Grassmann's external or internal multiplication in this memoir, which is concerned, as the title pretty clearly indicates, with the theory of the complex quantities of ordinary algebra.

It is difficult to understand the statements respecting the "Ausdehnungslehre," which seem to imply that Grassmann's two kinds of multiplication were subject to some kind of limitation to a plane. The external product is not limited in the first "Ausdehnungslehre" even to three dimensions. The internal, which is a comparatively simple matter, is mentioned in the first "Ausdehnungslehre" only in the preface, where it is defined, and placed beside the external product as relating to directed lines. There is not the least suggestion of any difference in the products in respect to the generality of their application to vectors.

The misunderstanding seems to have arisen from the following sentence in Grassmann's preface: "And in general, in the consideration of angles in space, difficulties present themselves, for the complete (*allseitig*) solution of which I have not yet had sufficient leisure." It is not surprising that Grassmann should have required more time for the development of some parts of his system, when we consider that Hamilton, on his discovery of quaternions, estimated the time which he should wish to devote to them at ten or fifteen years (see his letter to Prof. Tait in the *North British Review* for September 1866), and actually took several years to prepare for the press as many pages as Grassmann had printed in 1844. But any speculation as to the questions which Grassmann may have had principally in mind in the sentence quoted, and the particular nature of the difficulties which he found in them, however interesting from other points of view, seems a very precarious foundation for a comparison of the systems of Hamilton and Grassmann as published in the years 1843-44. Such a comparison should be based on the positive evidence of doctrines and methods actually published.

Such a comparison I have endeavoured to make, or rather to indicate the basis on which it may be made, so far as systems of geometrical algebra are concerned. As a contribution to analysis in general, I suppose that there is no question that Grassmann's system is of indefinitely greater extension, having no limitation to any particular number of dimensions.

J. Willard Gibbs.

The Flying to Pieces of a Whirling Ring.

In Nature of May 14 (p. 31) I notice a letter by Mr. C. A. Carus-Wilson on the rotation of a hollow steel flask, composed apparently of a spherical shell mounted on an axis constituting a diameter. Mr. Carus-Wilson speaks of this body as being under a "tension" of "31·5 tons per square inch" at a certain speed of rotation. He does not, however, specify what is the tension to which he refers, nor where it is found, neither does he give the density and elastic constants of the material nor indicate the method by which he arrived at his result.

So far as I know, the only problem of the kind which has yet been solved is that of an isotropic spherical shell[1] rotating about an imaginary axis through its centre at speeds at which the strains follow Hooke's law. This differs from the case Mr. Carus-Wilson speaks of, inasmuch as the existence of a real material axis must introduce conditions somewhat different from those assumed by the mathematical theory, and further the results obtained by this theory cannot legitimately be applied to speeds exceeding that where bulging becomes sensible, if indeed so far.

This solution is probably, however, the nearest to the practical problem at present attainable.

According to it the strains and stresses vary throughout the shell with the distance from the centre, and the angular distance from the axis of rotation. They also depend on the density and on the elastic properties of the material. There are also at every point three principal stresses, whereof one it is true vanishes over the surfaces. Thus such a statement as Mr. Carus-Wilson's requires further explanation.

According to the two theories most commonly entertained, the quantity which determines the limiting safe speed is the maximum value of either the *greatest strain* or the *maximum stress-difference*,—*i.e.* the algebraical difference between the greatest and least principal stresses at a point. Over the surfaces of the shell the absolutely greatest values of both these quantities are found, for shells of all degrees of thickness, in the equatorial plane—or plane through the centre perpendicular to the axis of rotation.

Denoting the angular velocity by ω, the radii of the outer and inner surfaces respectively by a and a', the density by ρ, Young's modulus by E, the greatest strain by s, the maximum stress-difference by S, and the stress at right angles to the meridian plane by Φ, the three last quantities being measured in the equator, the following are some of the results I found for materials in which Poisson's ratio is 1/4:—

	$Es/\omega^2\rho a^2$		$S/\omega^2\rho a^2$		$\Phi/\omega^2\rho a^2$	
	Inner surface.	Outer surface.	Inner surface.	Outer surface.	Inner surface.	Outer surface.
$a'/a = 0·9$	0·950	0·833	1·064	0·866	0·912	0·866
$\frac{a-a'}{a}$ negligible	1·0	1·0	1·0	1·0	1·0	1·0

Apparently in the case mentioned by Mr. Carus-Wilson, $a'/a = 15/16 = 0·9375$. Supposing the material to have Poisson's ratio = 1/4, which seems to accord fairly with experiments on steel, the approximate values of s, S, and Φ, for this case could be obtained by interpolation from those I give above. The differences between the values of corresponding strains and stresses at the two surfaces are less, of course, for $a'/a = 15/16$ than for $a'/a = 0·9$, but still are far from negligible. Mr. Carus-Wilson's numerical result rather suggests that the tension he refers to is the stress Φ, measured as above in the equator, and that he employed the formula $\Phi = \omega^2\rho a^2$. This formula (see Cambridge Philosophical Transactions, vol. xiv. p. 300), is correct for the value of Φ in the *equator* in an *infinitely thin* shell, but it does not strictly apply to any shell whose thickness is comparable with its radius. In the paper in the Cambridge Transactions first referred to, there are given tables of the numerical measures of the strains and stresses over the surfaces for a series of values of a'/a for materials in which Poisson's ratio is 1/4. These give by interpolation fairly accurate values for all values of a'/a. For other values of Poisson's ratio, recourse must be had to the general formulæ given in the paper, unless $\epsilon, \equiv 1 - a'/a$, is very small, when the greatest values of s and S are given approximately by $Es/\omega^2\rho a^2 = 1 - \frac{1}{2}\epsilon(1-\eta)$, $S/\omega^2\rho a^2 = 1 + \epsilon/(1+\eta)$, where η is Poisson's ratio (see Camb. Trans., vol. xiv. p. 304).

May 16. C. Chree.

[1] Cambridge Philosophical Society's Transactions, vol. xiv. pp. 467–483.

A Comet observed from Sunrise to Noon.

A short time ago I got the loan of an old number of *Harper's Monthly* (March 1889), good reading matter being very acceptable, however old, in this outlandish place, in which I read an article, on the origin of celestial species, by J. Norman Lockyer, F.R.S., Cor. Inst. France, that set me thinking of what I observed of the great comet of 1882, when it made its tremendous plunge round the sun, on September 18. At that time I was master of a small vessel, trading in the Society Islands; and on the day mentioned—in latitude 16° 25′ S., longitude 151° 57′ W. of Greenwich, a position about midway between the two islands Bolabola and Maupiti (the Maurua of Cook)—I saw, with the naked eye, the comet travel about 90° of the circle of the sun's disk, between sunrise and noon; but what made it most remarkable to us was that it should be possible for us, in a perfectly clear sky, to be able to watch it all, from sunrise to noon, with very little more distress to the eye than if in a clear night looking at a full moon.

Now, Sir, may it not be that this is partly a *proof* of the theory set forth by Norman Lockyer in the article above mentioned, viz. that comets are swarms of meteorites in collision, travelling through space, and that the outer invisible part of the swarm that formed this comet's nucleus had partially eclipsed the sun, like a veil over it? I am not aware if it was noticed by any competent astronomer or not, but the chances are that none had the splendid opportunity that we had to see the phenomena; so, Sir, knowing that men of science are always glad to get facts from observers in all parts of the world is my excuse for writing this to you, not knowing Mr. Lockyer's address. Thinking this, although late, may probably be of some interest to the scientific world, I leave you to do what you may think proper with it.

Wm. Ellacott.

Raiatea, January 30.

Graphic Daily Record of the Magnetic Declination or Variation of the Compass at Washington.

I beg to call your attention to the enclosed reprint from the May Pilot Chart of curves of magnetic declination as recorded at the United States Naval Observatory at Washington. This reprint admits of reproduction more readily than the curves as shown on the Pilot Chart, being in black and white, and only reduced to two-fifths of true size (the reduction on the Pilot Chart itself being one-quarter). It will be interesting to this Office to elicit expressions of opinion relative to the advantages of the prompt publication of these curves. The experiment is to be tried for three months, but it is not likely to be continued longer unless certain decided advantages develop. It may be of sufficient interest to Nature to republish these curves, and thus assist us in giving them wide publicity.

Richardson Clover,
Hydrographer.

Washington, D.C., May 6.

[We are unable to print the curves, but we may note that they are issued with the following explanation:—"These curves indicate graphically the true direction in which the magnetic needle at the Naval Observatory pointed during each instant from noon, March 29, to noon, April 30. The base-line shows a slight break at the end of each two hours, 75th meridian time, and the amount of westerly variation at any time is 4° *plus* the number of minutes represented by the height of the curve above the base line at that time, measured by the scale at the right or left margin of the diagram. The slight breaks in the curve itself occur when the chronograph sheets are changed. Although the daily change of variation at any one place, even in magnetic storms such as those that have occurred during the past month, is too small to be of any importance in practical navigation, yet it is thought that the prompt publication of these curves cannot fail to interest masters of vessels, as well as scientific men. The mean daily curve, which can be drawn by taking the average of many such curves, shows that there is a regular, though slight, daily change in the variation, somewhat analogous to the daily range of the barometer, although the daily minimum of variation at Washington occurs at about 8 a.m., and the maximum between 1 and 2 p.m. It is proposed to continue the publication of these curves on this Chart for at least three months, and any questions regarding them will receive immediate consideration and reply. The attention of masters of vessels is called to the form issued by this Office for the record of observations of variation at sea, and to the general importance of the subject in connection with vessels' compasses and the variation curves plotted on our charts."]

The Alpine Flora.

In connection with this subject (see Nature, vol. xliii. p. 581) it may be well to draw the attention of botanists to the fact that a young vigorous strawberry plant, in an exposed garden, will, during the winter season, place all its leaves in a perfectly horizontal position, some even close to and resting on the ground, in striking contrast to its summer habit of erect growth, whereby it is often damaged by strong winds.

Whether direct climatal conditions be the sole cause of this peculiarity, or whether inherited, I cannot determine; presumably, in its natural surroundings, the continual crowding and consequent struggle would not necessitate the adoption of dwarfing as a means of survival. J. Lovel.

May 13.

Magnetic Anomalies in Russia.

The magnetic disturbances in England and Wales as communicated to Nature, vol. xliii. p. 617, by M. Mascart and A. W. Rücker, are of great interest, but the size of the disturbances between Charkov and Kursk in Russia is of much higher value. More than 150 stations with magnetic elements have proved that in the above region there are points where the declination differs by 86°, the inclination by 29°, and the magnetic total force by 0·39 el. un. The principal centres are distant from each other not more than 12 kilometres. The m. elements are :—

Principal centres of disturbance.	Decl. °	Incl. °	Total force, e. u.
Nepchaevo	+ 48	+ 81	0·84
Visloe	− 33	+ 52	0·65
Kisselevo	− 38	+ 63	0·72
Sobinino	+ 30	+ 60	0·75
Petropavlovka	− 20	+ 76	0·80
Belgorod	− 36	+ 71	0·64

The normal values are − 1° Decl. ; + 64° Incl. ; 0·48 total force. The districts are covered by sedimentary rocks.

St. Petersburg, April 30. A. de Tillo.

THE REJUVENESCENCE OF CRYSTALS.[1]

Very soon after the invention of the microscope, the value of that instrument in investigating the phenomena of crystallization began to be recognized.

The study of crystal-morphology and crystallogenesis was initiated in this country by the observations of Robert Boyle ; and since his day a host of investigators—among whom may be especially mentioned Leeuwenhoek and Vogelsang in Holland, Link and Frankenheim in Germany, and Pasteur and Senarmont in France—have added largely to our knowledge of the origin and development of crystalline structures. Nor can it be said with justice that this field of investigation, opened up by English pioneers, has been ignobly abandoned to others ; for the credit of British science has been fully maintained by the numerous and brilliant discoveries in this department of knowledge by Brewster and Sorby.

There is no branch of science which is more dependent for its progress on a knowledge of the phenomena of crystallization than geology. In seeking to explain the complicated phenomena exhibited by the crystalline masses composing the earth's crust, the geologist is constantly compelled to appeal to the physicist and chemist ; from them alone can he hope to obtain the light of experiment and the leading of analogy, whereby he may hope to solve the problems which confront him.

But if geology owes much to the researches of those physicists and chemists who have devoted their studies to the phenomena of crystallization, the debt has been more than repaid through the new light which has been thrown on these questions by the investigation of naturally-formed crystals by mineralogists and geologists.

In no class of physical operations is *time* such an important factor as in crystallization ; and Nature, in producing her inimitable examples of crystalline bodies, has been unsparing in her expenditure of time. Hence it is not surprising to find that some of the most wonderful phenomena of crystallization can best be studied—some, indeed, can only be studied—in those exquisite specimens of Nature's handiwork which have been slowly elaborated by her during periods which must be measured in millions of years.

I propose to-night to direct your attention to a very curious case in which a strikingly complicated group of phenomena is presented in a crystalline mass: and these phenomena, which have been revealed to the student of natural crystals, are of such a kind that we can scarcely hope to reproduce them in our test-tubes and crucibles.

But if we cannot expect to imitate all the effects which have in this case been slowly wrought out in Nature's laboratory, we can, at least, investigate and analyze them ; and, in this way, it may be possible to show that phenomena like those in question must result from the possession by crystals of certain definite properties. Each of these properties, we shall see, may be severally illustrated and experimentally investigated, not only in natural products, but in the artificially-formed crystals of our laboratories.

In order to lead up to the explanation of the curious phenomena exhibited by the rock-mass in question, the first property of crystals to which I have to refer may be enunciated as follows :-

Crystals possess the power of resuming their growth after interruption; and there appears to be no limit to the time after which this resumption of growth may take place.

It is a familiar observation that if a crystal be taken from a solution and put aside, it will, if restored after a longer or shorter interval to the same or a similar solution, continue to increase as before. But geology affords innumerable instances in which this renewal of growth in crystals has taken place after millions of years must have elapsed. Still more curious is the fact, of which abundant proof can be given, that a crystal formed by one method may, after a prolonged interval, continue its growth under totally different conditions and by a very different method. Thus, crystals of quartz, which have clearly been formed in a molten magma, and certain inclosures of glass, may continue their growth when brought in contact with solutions of silica at ordinary temperatures. In the same way, crystals of felspar, which have been formed in a mass of incandescent lava, may increase in size, when solvent agents bring to them the necessary materials from an enveloping mass of glass, even after the whole mass has become cold and solid.

It is this power of resuming growth after interruption, which leads to the formation of zoned crystals, like the fine specimen of amethyst enclosed in colourless quartz, which was presented to the Royal Institution seventy years ago by Mr. Snodgrass.

The growth of crystals, like that of plants and animals, is determined by their environment ; the chief conditions affecting their development being temperature, rate of growth, the supply of materials (which may vary in

[1] The Friday Evening Discourse, delivered at the Royal Institution on January 30, 1891, by Prof. John W. Judd, F.R.S.

quality as well as in quantity), and the presence of certain foreign bodies.

It is a very curious circumstance that the form assumed by a crystal may be completely altered by the presence of infinitesimal traces of certain foreign substances—foreign substances, be it remarked, which do not enter in any way into the composition of the crystallizing mass. Thus there are certain crystals which can only be formed in the presence of water, fluorides, or other salts. Such foreign bodies, which exercise an influence on a crystallizing substance without entering into its composition, have been called by the French geologists "mineralizers." Their action seems to curiously resemble that of diastase, and of the bodies known to chemists as "ferments," so many of which are now proved to be of organic origin.

Studied according to their mode of formation, zoned crystals fall naturally into several different classes.

In the first place, we have the cases in which the successive shells or zones differ only in colour or some other accidental character. Sometimes such differently coloured shells of the crystal are sharply cut off from one another, while in other instances they graduate imperceptibly one into the other.

A second class of zoned crystals includes those in which we find clear evidence that there have been pauses, or, at all events, changes in the rate of their growth. The interruption in growth may be indicated in several different ways. One of the commonest of these is the formation of cavities filled with gaseous, liquid, or vitreous material, according to the way the crystal has been formed—by volatilization, by solution, or by fusion; the production of these cavities indicating rapid or irregular growth. Not unfrequently it is clear that the crystal, after growing to a certain size, has been corroded or partially resorbed in the mass in which it is being formed, before its increase was resumed. In other cases, a pause in the growth of the crystal is indicated by the formation of minute foreign crystals, or the deposition of uncrystallized material along certain zonal planes in the crystal.

Some very interesting varieties of minerals, like the Cotterite of Ireland, the red quartz of Cumberland, and the spotted amethyst of Lake Superior, can be shown to owe their peculiarities to thin bands of foreign matter zonally included in them during their growth.

A curious class of zoned crystals arises when there is a change in the habit of a crystal during its growth. Thus, as Lavalle showed in 1851 (*Bull. Géol. Soc. Paris*, 2me. sér., vol. viii. pp. 610–13), if an octahedron of alum be allowed to grow to a certain size in a solution of that substance, and then a quantity of alkaline carbonate be added to the liquid, the octahedral crystal, without change in the length of its axes, will be gradually transformed into a cube. In the same way, a scalenohedron of calcite may be found inclosed in a prismatic crystal of the same mineral, the length of the vertical axis being the same in both crystals.

By far the most numerous and important class of zoned crystals is that which includes the forms where the successive zones are of different, though analogous, chemical composition. In the case of the alums and garnets, we may have various *isomorphous* compounds forming the successive zones in the same crystal; while, in substances crystallizing in other systems than the cubic, we find *plesiomorphous* compounds forming the different enclosing shells.

Such cases are illustrated by many artificial crystals, and by the tourmalines, the epidotes, and the felspars among minerals. The zones, consisting of different materials, are sometimes separated by well-marked planes; but in other cases they shade imperceptibly into one another.

In connection with this subject it may be well to point out that zoned crystals may be formed of two substances which do not crystallize in the same system. Thus, crystals of the monoclinic augite may be found surrounded by a zone of the rhombic enstatite; and crystals of a triclinic felspar may be found enlarged by a monoclinic felspar.

Still more curious is the fact that, where there is a similarity in crystalline form and an approximation in the dominant angles (plesiomorphism), we may have zoning and intergrowth in the crystals of substances which possess no chemical analogy whatever. Thus, as Senarmont showed in 1856, a cleavage-rhomb of the natural calcic carbonate (calcite), when placed in a solution of the sodic nitrate, becomes enveloped in a zone of this latter substance; and Tschermak has proved that the compound crystal thus formed behaves like a homogeneous one, if tested by its cleavage, by its susceptibility to twin lamellation, or by the figures produced by etching. In the same way, zircons, which are composed of the two oxides of silicon and zirconium, are found grown in composite crystals with xenotime, a phosphate of the metals of the cerium and yttrium groups.

These facts, and many similar ones which might be adduced, point to the conclusion that the beautiful theory of isomorphism, as originally propounded by Mitscherlich, stands in need of much revision as to many important details, if not, indeed, of complete reconstruction, in the light of modern observation and experiment.

The second property of crystals to which I must direct your attention is the following:—

If a crystal be broken, or mutilated in any way whatever, it possesses the power of repairing its injuries during subsequent growth.

As long ago as 1836, Frankenheim showed that, if a drop of a saturated solution be allowed to evaporate on the stage of a microscope, the following interesting observations may be made upon the growing crystals. When they are broken up by a rod, each fragment tends to re-form as a perfect crystal; and if the crystals be caused to be partially re-dissolved by the addition of a minute drop of the mother liquor, further evaporation causes them to resume their original development (*Pogg. Ann.*, Bd. xxxvii., 1836).

In 1842, Hermann Jordan showed that crystals taken from a solution and mutilated gradually became repaired or healed when replaced in the solution (*Müller Archiv. für* 1842, pp. 46–56). Jordan's observations, which were published in a medical journal, do not, however, seem to have attracted much attention from the physicists and chemists of the day.

Lavalle, between the years 1850 and 1853,[1] and Kopp, in the year 1855, made a number of valuable observations bearing on this interesting property of crystals (*Liebig Ann.*, xciv., 1855, pp. 118–25). In 1856 the subject was more thoroughly studied by three investigators who published their results almost simultaneously: these were Marbach (*Compt. rend.*, xliii., 1856, pp. 705–706, 800–802), Pasteur (*ibid.*, pp. 795–800), and Senarmont (*ibid.*, p. 799). They showed that crystals taken from a solution and mutilated in various ways, upon being restored to the liquid became completely repaired during subsequent growth.

As long ago as 1851, Lavalle had asserted that, when one solid angle of an octahedron of alum is removed, the crystal tends to reproduce the same mutilation on the opposite angle, when its growth is resumed! This remarkable and anomalous result has, however, by some subsequent writers been explained in another way to that suggested by the author of the experiment.

In the same way the curious experiments performed at a subsequent date by Karl von Hauer, experiments which led him to conclude that hemihedrism and other pecu-

[1] *Bull. Géol. Soc. Paris*, 2me sér., vol. viii. pp 610–13, 1851; Moigno, *Cosmos*, ii, 1853, pp. 454–56; *Compt. rend.*, xxxvi., 1853, pp. 493–95.

liarities in crystal growth might be induced by mutilation,[1] have been asserted by other physicists and chemists not to justify the startling conclusions drawn from them at the time. It must be admitted that new experiments bearing on this interesting question are, at the present time greatly needed.

In 1881, Loir demonstrated two very important facts with regard to growing crystals of alum (*Compt. rend.*, Bd. xcii. p. 1166). *First*, that if the injuries in such a crystal be not too deep, it does not resume growth over its general surface until those injuries have been repaired. *Secondly*, that the injured surfaces of crystals grow more rapidly than natural faces. This was proved by placing artificially-cut octahedra and natural crystals of the same size in a solution, and comparing their weight after a certain time had elapsed.

The important results of this capacity of crystals for undergoing healing and enlargement, and their application to the explanation of interesting geological phenomena has been pointed out by many authors. Sorby has shown that, in the so-called crystalline sand-grains, we have broken and worn crystals of quartz, which, after many vicissitudes and the lapse of millions of years, have grown again and been enveloped in a newly formed quartz-crystal. Bonney has shown how the same phenomena are exhibited in the case of mica, Becke and Whitman Cross in the case of hornblende, and Merrill in the case of augite. In the felspars of certain rocks it has been proved that crystals that have been rounded, cracked, corroded, and internally altered—which have, in short, suffered both mechanical and chemical injuries—may be repaired and enlarged with material that differs considerably in chemical composition from the original crystal.

It is impossible to avoid a comparison between these phenomena of the inorganic world and those so familiar to the biologist. It is only in the lowest forms of animal life that we find an unlimited power of repairing injuries: in the Rhizopods and some other groups a small fragment may grow into a perfect organism. In plants the same phenomenon is exhibited much more commonly, and in forms belonging to groups high up in the vegetable series. Thus, parts of a plant, such as buds, bulbs, slips, and grafts, may—sometimes after a long interval—be made to grow up into new and perfect individuals. But in the mineral kingdom we find the same principle carried to a much farther extent. We know, in fact, no limit to the minuteness of fragments which may, under favourable conditions, grow into perfect crystals—no bounds as to the time during which the crystalline growth may be suspended in the case of any particular individual.

The next property of crystals which I must illustrate, in order to explain the particular case to which I am calling your attention to-night, is the following:—

Two crystals of totally different substances may be developed within the space bounded by certain planes, becoming almost inextricably intergrown, though each retains its distinct individuality.

This property is a consequence of the fact that the substance of a crystal is not necessarily continuous within the space inclosed by its bounding planes. Crystals often exhibit cavities filled with air and other foreign substances. In the calcite crystals found in the Fontainebleau sandstone, less than 40 per cent. of their mass consists of calcic carbonate, while more than 60 per cent. is made up of grains of quartz-sand, caught up during crystallization.

[1] *Wien. Sitz. Ber.*, xxxix., 1860, pp. 611–22; Erdmann, *Journ. Prakt. Chem.*, lxxxi. pp. 356–62; *Wien. Geol. Verhandl.*, xii. pp. 212–13, &c.; Frankenheim, *Pogg. Ann.*, cxiii., 1861. Compare Fr. Scharff, *Pogg. Ann.*, cix., 1860, pp. 529–38; *Neues Jahrb. für Min.*, &c., 1876, p. 24; and W. Sauber, *Liebig Ann.*, cxxiv., 1862. pp. 78–82; also W. Ostwald, "Lehrbuch d. Allg. Chem.," 1885, Bd. i. p. 738; and O. Lehmann, "Molekular Physik.," 1888, Bd. i. p. 312.

In the rock called "graphic granite," we have the minerals orthoclase and quartz intergrown in such a way that the more or less isolated parts of each can be shown, by their optical characters, to be parts of great mutually interpenetrant crystals. Similar relations are shown in the so-called micro-graphic or micro-pegmatitic intergrowths of the same minerals which are so beautifully exhibited in the rock under our consideration this evening.

There is still another property of crystals that must be kept in mind, if we would explain the phenomena exhibited by this interesting rock:—

A crystal may undergo the most profound internal changes, and these may lead to great modifications of the optical and other physical properties of the mineral; yet, so long as a small—often a very small—proportion of its molecules remain intact, the crystal may retain, not only its outward form, but its capacity for growing and repairing injuries.

Crystals, like ourselves, grow old. Not only do they suffer from external injuries, mechanical fractures, and chemical corrosion, but from actions which affect the whole of their internal structure. Under the influence of the great pressures in the earth's crust, the minerals of deep-seated rocks are completely permeated by fluids which chemically react upon them. In this way, negative crystals are formed in their substance (similar to the beautiful "ice-flowers" which are formed when a block of ice is traversed by a beam from the sun or an electric lamp), and these become filled with secondary products. As the result of this action, minerals, once perfectly clear and translucent, have acquired cloudy, opalescent, iridescent, avanturine, and "schiller" characters; and minerals, thus modified, abound in the rocks that have at any period of their history been deep-seated. As the destruction of their internal structure goes on, the crystals gradually lose more and more of their distinctive optical and their physical properties, retaining, however, their external form; till at last, when the last of the original molecules is transformed or replaced by others, they pass into those mineral corpses known to us as "pseudomorphs."

But while crystals resemble ourselves in "growing old," and, at last, undergoing dissolution, they exhibit the remarkable power of growing young again, which we, alas! never do. This is in consequence of the following remarkable attribute of crystalline structures:—

It does not matter how far internal change and disintegration may have gone on in a crystal—if only a certain small proportion of the unaltered molecules remain, the crystal may renew its youth and resume its growth.

When old and much-altered crystals begin to grow again, the newly-formed material exhibits none of those marks of "senility" to which I have referred. The sand-grains that have been battered and worn into microscopic pebbles, and have been rendered cloudy by the development of millions of secondary fluid cavities, may have clear and fresh quartz deposited upon them to form crystals with exquisitely perfect faces and angles. The white, clouded, and altered felspar-crystals may be enveloped by a zone of clear and transparent material, which has been added millions of years after the first formation and the subsequent alteration of the original crystal.

We are now in a position to explain the particular case which I have thought of sufficient interest to claim your attention to-night.

In the Island of Mull, in the Inner Hebrides, there exist masses of granite of Tertiary age, which are of very great interest to the geologist and mineralogist. In many places this granite exhibits beautiful illustrations of the curious intergrowths of quartz and felspar, of which I have already spoken. Such parts of the rock often abound with cavities (druses), which I believe are not of original but of secondary origin. At all events, it can be shown that these cavities have been localities in which crystal growth has gone on—they constitute indeed veritable laboratories of synthetic mineralogy.

Now, in such cavities the interpenetrant crystals of quartz and felspar in this rock have found a space where they may grow and complete their outward form; and it is curious to see how sometimes the quartz has prevailed over the felspar and a pure quartz-crystal has been produced; while at other times the opposite effect has resulted, and a pure felspar individual has grown up. In these last cases, however much the original felspar may have been altered (kaolinized and rendered opaque), it is found to be completed by a zone of absolutely clear and unaltered felspar-substance. The result is that the cavities of the granite are lined with a series of projecting crystals of fresh quartz and clear felspar, the relations of which to the older materials in an altered condition composing the substance of the solid rock, are worthy of the most careful observation and reflection.

Those relations can be fully made out when thin sections of the rock are examined under the microscope by the aid of polarized light, and they speak eloquently of the possession by the crystals of all those curious peculiarities of which I have reminded you this evening.

By problems such as those which we have endeavoured to solve to-night, the geologist is beset at every step. The crust of our globe is built up of crystals and crystal fragments—of crystals in every stage of development, of growth, and of variation—of crystals undergoing change, decay, and dissolution. Hence the study of the natural history of crystals must always constitute one of the main foundations of geological science; and the future progress of that science must depend on how far the experiments carried on in laboratories can be made to illustrate and explain our observations in the field.

BRITISH INSTITUTE OF PREVENTIVE MEDICINE.

A VIGOROUS attempt is being made by ignorant and prejudiced persons to prevent the establishment of a National Hygienic Institute worthy of the United Kingdom. A deputation will wait upon Sir Michael Hicks-Beach, President of the Board of Trade, on Friday, June 5, to submit to him an exact statement of the facts relating to the matter. Meanwhile, the Executive Committee has issued the following circular:—

On Monday afternoon, July 1, 1889, a meeting was held at the Mansion House, under the Presidency of Sir James Whitehead, Bart., then Lord Mayor of London, "for the purpose of hearing statements from Sir James Paget, and other representatives of scientific and medical opinion, with regard to the recent increase of rabies in this country, and the efficacy of the treatment discovered by M. Pasteur for the prevention of hydrophobia."

Although convinced of the advantages likely to accrue to the community at large by the founding of a Bacteriological Institute in England, the Committee felt that the time was not then come for establishing in England an institute similar to the "Institut Pasteur" in Paris, or the "Hygienische Institut" in Berlin. The idea, however, was not abandoned, and on December 5, 1889, an Executive Committee was appointed to take measures for the purpose of establishing in England a British Institute of Preventive Medicine.

Acting on the advice of their solicitors, Messrs. Hunters and Haynes, the Executive Committee decided to incorporate the Institute as a limited liability company, with the omission of the word "Limited," in order to impress the public with the fact that the Institute was not established for purposes of gain, but for purely charitable and scientific objects.

The application was lodged at the Board of Trade on February 13, 1891, and, shortly afterwards, a number of petitions were sent in asking the Board of Trade to withhold its license, as the objects of the Institute "clearly pointed to experiments on living animals." As Chairman of the Committee, Sir Joseph Lister then wrote to the President of the Board of Trade, showing why, in the opinion of the Committee, their opponents should not gain their point. In the first place, he pointed out that the granting of a vivisection license is not within the province of the Board of Trade, but under the control of the Secretary of State for the Home Department. In the second place, he clearly proved that it is absolutely necessary that the Institute should be licensed in the manner described, for it could not be registered under the Companies Act, 1862, without most seriously interfering with its prospects. From counsel's opinion it is evident that, should the Institute be registered as an ordinary limited liability company under the Act, it would at any time be possible for the members to wind up the company and divide the funds of the Institute; whereas the Board of Trade, in granting the license asked for, would make it a condition that all the property of the Institute should be applied to the advancement of science and kindred subjects only, and not be distributed among the members. In this way only could security be given that the funds would be applied for the purposes intended.

This letter was posted by one of the secretaries on May 12, 1891; but on the same day the solicitors to the Executive Committee received a letter from the President of the Board of Trade, who, without giving any reason whatever for his decision, declined to grant the application. On the next day, however, Sir Joseph Lister received a letter in answer to that posted on May 12, in which the President of the Board of Trade intimated his willingness to receive a deputation on June 5 at 11 a.m.

Workers in bacteriological science are now labouring under considerable difficulties, as there is no place in the United Kingdom specially fitted for such research. By the establishing of this Institute, they would be placed in the best possible conditions for carrying out original investigations. Moreover, a central Institute for the systematic teaching of bacteriology would be provided, not only for medical men, but also for veterinary surgeons, chemists, agriculturists, &c.

At present, in spite of the efforts made in this direction by several medical schools, most of the English workers who wish to gain special knowledge in bacteriology, are compelled to go to the Continental laboratories for their instruction. The question, therefore, which the Board of Trade will have to decide is, whether such a state of things should continue, or whether England should have its own national bacteriological Institute. Similar Institutes have been endowed by the State in other countries; and the Board of Trade, by refusing to grant their application, would prevent a body of private gentlemen from doing what has been done at great expense by the Governments of other nations.

NOTES.

WE are informed that Kew has recently acquired by purchase from Mr. F. Curtis, a descendant of William Curtis, the founder of the *Botanical Magazine*, about 1650 original drawings, chiefly of figures which appeared in that publication. They belong partly to the first series and partly to the second, from 1800 to 1826—that is to say, during the period that the magazine was edited by Dr. Sims. Many of these drawings are very beautiful, and very carefully coloured, especially those done by James

Sowerby and Sydenham Edwards; but some of the finest of their work was not reproduced in the plates. The collection also includes some of the poorest work that ever appeared in the magazine. In 1815 Sydenham Edwards seceded, and worked for the rival *Botanical Register;* Sowerby had ceased contributing, and there seems to have been a lack of novelties for illustration. Towards the end of Dr. Sims's editorship, in 1826, the *Botanical Magazine* was doubtless supplanted in a great measure by the *Botanical Register* then conducted by the vigorous Lindley. Its circulation greatly decreased, and the impression was small; hence this series is very rare. The following year, however, Sir William Hooker became editor and speedily raised both the artistic and botanical character of the magazine. Many of the plates published during the latter half of Dr. Sims's editorship are not signed, but all the drawings are, and we learn that William Hooker, the artist of the *Paradisus Londinensis,* was an occasional contributor. The collection also contains a number of unpublished drawings.

A LETTER lately received from Emin Pasha by one of his ornithological correspondents in Europe is dated from one of the larger islands on Lake Victoria Nyanza in November last. It is full of details about birds, in which, as is well known, the Pasha takes the keenest interest, and alludes especially to an apparently new *Gralline* form, with three toes, met with in that district. Emin was on the point of starting southwards into the territory near the north end of Lake Tanganyika, and is now probably somewhere in that little-known country. He had been joined by Dr. Stuhlman, a young naturalist of Hamburg. Dr. G. Hartlaub, of Bremen, has just published a memoir on the birds collected by Emin during his return to the coast with the Stanley Expedition, and his subsequent sojourn at Bagamoyo. The specimens are referred to 140 species, of which eight are described as new to science.

THE Council of the Institution of Naval Architects has resolved to award the gold medal of the Institution to Prof. V. B. Lewes for his paper on boiler deposits, read at the Institution's recent annual general meeting.

THE President of the Royal Society, who is Chairman of the Board of Visitors, will hold the annual visitation of the Royal Observatory at Greenwich on Saturday, June 6 next. The Observatory will be open for inspection at 3 p.m.

MR. JAMES E. KEELER, the Astronomer of the Lick Observatory, has lately been appointed Director of the Allegheny Observatory, in succession to Mr. S. P. Langley, Secretary of the Smithsonian Institution.

A CZECH Academy of Sciences was opened at Prague on the 18th inst., by the Archduke Charles Louis. The Latin title of the Academy is Bohemica Scientiarum, litterarum et artium Academia Imperatoris Francisci Josephi; the President is Josef Hlávka, and the General Secretary Dr. F. J. Studnička.

AN extra evening meeting of the Royal Institution will be held on Tuesday, June 2, at nine o'clock, when Dr. Charles Waldstein will give a discourse on the discovery of "The Tomb of Aristotle."

AMERICAN papers announce the death of Prof. J. E. Hilgard, late superintendent of the U.S. Coast Survey. He was born at Zweibrücken in 1825, went to America with his father in 1835, and entered the service of the U.S. Coast Survey in 1845. "His work," says the New York *Nation,* "lay directly in the line of his profession, in the improvement of methods, the determination of weights and measures, and the novel method of ascertaining the differences of longitude by telegraph. His publications on these subjects are to be found chiefly in the Coast Survey Reports. One of the most noteworthy relates to the telegraphic determination of the differences of longitude between Greenwich, Paris, and Washington. He was a delegate to the International Metric Commission in 1872, and a member of the International Bureau of Weights and Measures, of which he declined the directorship. He was an original member of the National Academy of Sciences, and for some years its Home Secretary. In 1874 he was elected President of the American Association for the Advancement of Science. He succeeded to the work of Bache in connection with the work of the Bureau of Weights and Measures, and took a leading part in preparing exact metric standards for distribution to the States and Territories."

THE recent botanical mission of Mr. D. Morris to the West Indies forms the subject of the *Kew Bulletin* for May and June. The *Bulletin* publishes the official correspondence recording the circumstances under which the Imperial Government assented to Mr. Morris's mission, and reproduces his report to the Secretary of State for the Colonies.

THE *Kew Bulletin* does good service by publishing lists of garden plants annually described in botanical and horticultural publications, both English and foreign. In Appendix II., 1891, there is a list which comprises all the new introductions recorded during 1890. "These lists," says the *Bulletin,* "are indispensable to the maintenance of a correct nomenclature, especially in the smaller botanical establishments in correspondence with Kew, which are, as a rule, only scantily provided with horticultural periodicals. Such a list will also afford information respecting new plants under cultivation at this establishment, many of which will be distributed from it in the regular course of exchange with other botanic gardens."

ON the 13th inst. the Council of the county borough of Bootle decided to appropriate and set aside for the purpose of technical education the whole of the portion of the Exchequer contribution account which may so be used under the provision of the Local Taxation (Customs and Excise) Act, 1890. The Free Library and Museum Committee were entrusted with the carrying out of a scheme submitted by them to the Council; and they have appointed Mr. John J. Ogle to the office of Organizing Secretary to the Bootle Technical School. Mr. C. H. Hunt was also appointed Registrar. The sum available is estimated at £1936 per annum.

THE following is an extract from the *Times* of last week which may interest many of our readers:—Some months ago a company, which had been formed at Wheeling, West Virginia, for the purpose of "developing" that city, began to drill a well in search of petroleum or natural gas. A depth of over 4100 feet was reached, and in this distance a dozen thick veins of coal are said to have been passed, while petroleum and gas have both been struck—though not in paying quantities—and gold quartz, iron ore, and many other minerals have been brought to the surface. The officers of the Geological Survey at Washington, according to a Wheeling despatch, have become very interested in the proceeding, and "the hole will be drilled to a depth of one mile." After this the Government will take up the work under the direction of two expert officers of the Survey, and the drilling will be continued into the earth as far as human skill can penetrate. The object is to ascertain the thermometric and magnetic conditions as far as possible.

THE Transandine Railway across the Andes, connecting the Argentine railway system with that of Chili, has been the subject of an interesting article in *Engineering.* Our contemporary in its issue of this week again deals with this fine piece of engineering, and describes the tunnelling plant used, as well as the distribution by electrical means of the power available and necessary for driving the air compressors for the Ferroux rock drills used. This line across the Andes consists of a series of tunnels and other heavy works; the tunnels had to be bored in most inaccessible regions, where the means of transport are meagre in the extreme. The whole of the plant therefore had to be designed with great care and with special reference to the unusual requirements. Weight had to be minimized, and strength and simplicity had to be carefully obtained. Water-power was available at some distance from the scene of operations; the water-power was brought to the primary stations by means of 20-inch steel pipes. On the Chilian side the primary station contained ten dynamos and two spare ones, each being of 80 horse-power, and each coupled direct to, and driven by, a Girard turbine. The electric power generated is transmitted through a cable to secondary stations, where, by means of motors, the air-compressors are operated. A similar arrangement is in use on the Argentine side, only the dynamos are of 40 horse-power, because they had to be transported over mountains on mules' backs, which made it necessary to minimize the weight. This use of the electrical transmission of power is highly interesting, the circumstances being such that, without it, the boring of the tunnels would have been a work of great expense and magnitude.

Globus has received information from Japan to the effect that there is an increasing reaction in the country against foreign influences. This is said to be especially visible in schools where European instruction is given. Two such schools, one of which formerly had 300 pupils, the other 150, have been obliged to combine their forces, having no more than 150 pupils between them. At the University of Tokio the number of native lecturers increases, while that of the foreign staff decreases.

IN the New York *Sun*, Mr. G. F. Kunz, the well-known expert in gems, has recently called attention to a property of the diamond which may serve as a means of distinguishing it from other substances. Referring to the paper of Robert Boyle "On a Remarkable Diamond that Shines in the Dark," published in the Transactions of the Royal Society in 1663, Mr. Kunz remarks that this paper has been indirectly alluded to by a number of authors, but never read. Among a quantity of facts Boyle mentions one diamond that phosphoresced simply by the heat of the hand, absorbed light by being held near a candle, and emitted light on being rubbed. He stated that many diamonds emitted light by being rubbed in the dark. The experiments made by Mr. Kunz show conclusively not only that Boyle's statement that some diamonds phosphoresce in the dark after exposure to the sunlight or an arc of electric light is true, but also that all diamonds emit light by rubbing them on wood, cloth, or metal, a property which will probably prove of great value in distinguishing between the diamond and other hard stones, as well as paste, none of which exhibit this phenomenon, and will be welcomed by the general public who do not possess the experience of the dealer in diamonds. The property is evidently not electric, or it would not be visible on being rubbed on metal.

WE learn from the *American Meteorological Journal* for April that the appropriation for the new Weather Service of the United States is 879,753 dollars, being an increase of 62,797 dollars on the amount for the current year. This is accounted for by the addition of 50,000 dollars for the proposed extension of the service in agricultural regions, and by the fact that, under the present arrangement, five of the leading officials were assigned from the army, and their salaries must henceforward be provided for from the appropriation for the new Weather Service. The Chief of the Service is to receive 4500 dollars a year. No appointment has yet been made to this position. It is quite possible that the present Chief Signal Officer will be detailed from the army for this duty, and Prof. Abbe, Prof. W. M. Davis, Prof. Nipher, and Dr. Hinrichs are some of the other prominent meteorologists mentioned as possible candidates. The same *Journal* also reports that Dr. Baker, Secretary of the Michigan State Board of Health, has investigated the cause of influenza. He stated that the germs are at all times present, but that there must be certain coincident meteorological conditions to irritate the throat and air passages sufficiently to let the germ gain an entrance to the body. These conditions were, in this instance, the excessive prevalence of north and north-east winds, and the excessive amount of ozone during the past three months.

MR. C. L. WRAGGE has issued a circular, dated February 3 last, stating that "in consequence of the rapid extension of the Meteorological Service of Australasia in connection with the Queensland Government—an extension which now embraces a large portion of the Western Pacific Ocean, New Guinea, and the Malay Archipelago—it has been determined to stop the issue of the large charts which have hitherto dealt with the meteorology of Australasia only, and to issue, instead, in the early future, a weather chart as complete as possible, embracing not only Australasia, but also the regions above indicated." Some charts have already been issued giving the isobaric lines for the region referred to, and extending southwards and eastwards to New Zealand and the New Hebrides. Isobars drawn for 20° to 30° to the eastward of Brisbane must be to a great extent problematical, and in fact this is admitted by the broken lines extending over the ocean. The information, to say the least, seems at present insufficient for the purpose, and over large tracts it is absolutely wanting; but the establishment of stations in remote islands is, of itself, very desirable.

THE other day Prof. Vambéry delivered in Edinburgh, under the auspices of the Royal Scottish Geographical Society, an interesting lecture on British civilization and influence in Asia. He had many pleasant things to say about England, but did not quite overlook her shortcomings. He said he was immensely struck by the indifference shown by the public at large to everything that concerned Asia. He had lectured in more than 20 towns in this country, and found, even amongst the middle classes, great ignorance in regard to Asiatic geography and ethnography. Asiatic languages, moreover, were greatly neglected. Germany, which had not got any territory in Asia, bestowed far greater attention upon the old world than this country. He opined that if the interest in Asia would increase in this country commensurately with its political power and influence over the various races in Asia, Britain would decidedly remain there a permanent Power which could never be ousted by any rival. He thought that there ought to be more schools for Oriental languages in this country. There was a general supposition that Britons in general could not learn foreign languages, but that was not true. The greatest linguists of our age had been British, as, for example, Lord Strangford for Turkish, and the late Sir Richard Burton and the late Prof. Palmer for Arabic. Then there were scholars like Sir James Redhouse, Sir Henry Rawlinson, Sir William White, and many others bearing evidence of the brilliant linguistic capacity of the British. He believed that nothing could be easier than to recruit in this island a goodly number of Oriental linguists for employment in various Asiatic countries.

A PAPER by Messrs. G. F. Harris and H. W. Burrows, on the Eocene and Oligocene beds of the Paris Basin, is to be issued as a separate publication by the Geologists' Association. It will be illustrated by a map and sections. The paper is the result of several years' careful study of the Parisian Tertiaries, and close communication with many eminent French geologists. The authors give an elaborate appendix, consisting of a list of the fossil Mollusca, some 3500 species, showing the range in time; the nomenclature of each species has been critically revised and brought up to date. Careful attention has also been paid to the relationship between recent and Tertiary forms. The generic names under which most of the shells are still known in this country are added as an assistance to the student.

THE Physical Society of London has published the first part of the eleventh volume of its Proceedings. Among the contents are notes on photographs of rapidly moving objects, and on the oscillating electric spark, by Mr. C. V. Boys; a formula for calculating approximately the self-induction of a coil, by Prof. John Perry; a lecture experiment illustrating the effect of heat upon the magnetic susceptibility of nickel, by Mr. Shelford Bidwell; and experiments in photo-electricity, by Prof. G. M. Minchin.

A LECTURE by Prof. A. Macalister, delivered on January 29, on the opening of the new anatomical lecture-room at Cambridge, has been published by the Cambridge University Press. The subject is "The History of the Study of Anatomy in Cambridge."

MESSRS. CHARLES GRIFFIN AND CO. have published the eighth annual issue of the "Year-book of the Scientific and Learned Societies of Great Britain and Ireland." The work is compiled from official sources, and comprises lists of the papers read during 1890 before Societies engaged in fourteen departments of research, with the names of their authors.

THE Engineering Company, publishers, New York, are issuing a new monthly magazine, entitled *Engineering*, which is to be wholly devoted to the record of industrial progress. The first two numbers have been published.

THERE are some valuable morphological notes in the Johns Hopkins University Circulars for May. Among other papers we may mention one on the structure and development of the gonophores of a certain Siphonophore belonging to the order Auronectæ (Haeckel), by W. K. Brooks and E. G. Conklin. Other papers are: preliminary notes on some new species of Squilla, by R. P. Bigelow, and a preliminary note on the anatomy and transformation of Tornaria, by T. H. Morgan.

THE "Bibliothèque Évolutioniste" is the general title of a new scientific series which is being published in Paris. The editor is M. Henry de Varigny. The first volumes are mostly translations, Wallace's "Darwinism" opening the list; but French authors are also to contribute, and works are being prepared by Messrs. A. Sabatier, of Montpellier; J. Deniker, the well-known anthropologist; Prof. Giard, and others.

IN NATURE for May 14, p. 36, line 5 from top, or "1887" read "1889."

A NEW and very beautiful silver mineral is described by Mr. F. A. Genth in the May number of the *American Journal of Science*. It was discovered by Señor Aguilar, of the San Carlos Silver Mine at Guanajuato, Mexico, and has been named after him, aguilarite. It is a sulpho-selenide of silver, of the composition $Ag_2S + Ag_2Se$, the analyses of pure crystals agreeing exactly with this formula. The crystals are iron-black in colour, and possess a most brilliant lustre. They belong to the cubic system, and consist of curious skeleton dodecahedrons, the edges of which are perfect, while the centres of the faces are more or less worn or imperfectly developed. These dodecahedrons are frequently elongated in such a manner as to resemble either tetragonal prisms terminated by pyramids of the opposite order, or hexagonal prisms terminated by rhombohedral planes. They generally occur in interlaced and closely aggregated groups, the individual crystals of which attain a size of a centimetre or more in diameter. They are for the most part embedded in colourless calcite, which may readily be removed from them by means of dilute acetic acid; frequently a little quartz is associated with them. The crystals are readily sectile and malleable, and their hardness is only 2·5. Their specific gravity is 7·586. When heated in an open tube to low redness, gradually increasing to bright redness, they yield metallic silver, together with a slight sublimate of selenium, and slender needles of selenious and sulphuric oxides, which latter forms, with a little of the silver, silver sulphate. In many of the specimens of aguilarite examined, the crystals were observed to be penetrated in a remarkable manner by round holes, and they also frequently exhibited deposits of pure metallic silver upon their faces.

SEVERAL of the simpler sulphides of the organic radicles have been found to occur naturally in the crude petroleum oil of Ohio by Messrs. Mabery and Smith, who describe the mode adopted for their isolation in the current number of the *American Chemical Journal*. As far as they are aware, these alkyl sulphides have never previously been found in nature. When the higher boiling fractions of the distilled oil are agitated with oil of vitriol, these sulphur compounds are taken up by the sulphuric acid, and, upon subsequently neutralizing the acid solution with slaked lime, unstable calcium salts are obtained, which are readily decomposed by distillation in steam, which carries over the sulphides without decomposition. By employing these reactions upon a large scale, and afterwards subjecting the mixed sulphides to a rigorous fractional distillation under reduced pressure (150 mm. being the most convenient working pressure), the following sulphides have been isolated: methyl sulphide, $(CH_3)_2S$; ethyl sulphide, $(C_2H_5)_2S$; normal propyl sulphide, $(C_3H_7)_2S$; normal and iso-butyl sulphides, $(C_4H_9)_2S$; amyl sulphide, $(C_5H_{11})_2S$; hexyl sulphide, $(C_6H_{13})_2S$; and a few other sulphides of mixed radicles. Most of these sulphides were obtained in the pure state by treating the products of the fractionation with mercuric chloride, and thus obtaining crystals of the addition compounds of the type $(CH_3)_2S \cdot HgCl_2$, and subsequently decomposing these crystals of the mercury compounds with sulphuretted hydrogen.

THE additions to the Zoological Society's Gardens during the past week include a Barbary Ape (*Macacus inuus* ♂) from North Africa, presented by the Rev. G. H. Watkins; a Diuca Finch (*Diuca grisea*), two Gay's Finches (*Phrygilus gayi*) from Chili, two De Filippi's Meadow Starlings (*Sturnella defilippi*) from La Plata, presented by Mr. Charles G. Sharpe; two Bankiva Jungle Fowls (*Gallus bankiva* ♂ ♀) from India, presented by Captain George James; a Common Rhea (*Rhea americana*) from South America, presented by Mr. R. P. Houston; an Algerian Tortoise (*Testudo mauritanica*) from North Africa, presented by Mrs. Margaret Clarke; a Black-eared Marmoset (*Hapale penicillata*) from South-east Brazil, presented by Mr. Aubrey Lace; a Capybara (*Hydrochærus capybara*), a Brown Milvago (*Milvago chimango*), a Violaceous Night Heron (*Nycticorax violaceus*) from South America, two Blue-bearded Jays (*Cyanocorax cyanopogon*) from Para, four Crested Screamers (*Chauna chavaria*) from Buenos Ayres, deposited; two Variegated Sheldrakes (*Tadorna variegata*) from New Zealand, two Larger Tree Ducks (*Dendrocygna major*) from India, purchased; two Japanese Deer (*Cervus sika* ♂ ♀), a Chinchilla (*Chinchilla lanigera*), an African Wild Ass (*Equus tæniopus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

THE DRAPER CATALOGUE OF STELLAR SPECTRA.—Vol. xxvii. of the *Annals of the Astronomical Observatory of Harvard College* contains a catalogue of the spectra of 10,351 stars, nearly all of them north of the parallel of declination − 25°, photographed with the 8-inch Bache telescope. As the work forms a part of the Henry Draper Memorial, it is suggested that it be designated as the Draper Catalogue. In order to produce the spectra, a prism 8 inches square and having a refracting angle of 13°, was fastened in front of the object-glass, with its refracting angle placed perpendicular to the earth's axis. The spectra obtained have been conveniently arranged in classes indicated by the letters A to Q. Of these, A, B, C, and D indicate varieties of Secchi's first type, E to L varieties of the second type, M the third type, and N the fourth type. The letter O is used for stars whose spectra consist mainly of bright lines, and the letter P is reserved for planetary nebulæ. The classes O and P closely resemble each other, and are regarded by Prof. Pickering as a fifth type of spectrum. All spectra not included in these classes are indicated by the letter Q. Viewed as the result of a preliminary survey of the types of the photographic spectra of stars, the catalogue is of the highest importance. But it is to the discussion of individual lines, which is to follow in another volume, that we have to look for detailed information which may improve our knowledge of stellar constitution.

Solar Observations from January to March 1891.—In *Comptes rendus*, No. 19 (May 11, 1891), Prof. Tacchini gives the following account of solar activity during the first three months of this year.

Observations of spots and faculæ have been made on 64 days, viz. 16 in January, 26 in February, and 22 in March. The results obtained are :—

1891.	Relative frequency of spots.	Relative frequency of days without spots.	Relative magnitude of spots.	Relative magnitude of faculæ.	Number of groups per day.
January	1·56	0·30	18″·50	16″·88	1·38
February	2·31	0·15	24·04	89·62	2·38
March	1·27	0·14	11·91	41·82	1·45

The following are the results of observations of hydrogen prominences :—

1891.	Number of days of observation.	Prominences: Mean number.	Prominences: Mean height.	Prominences: Mean extension.
January	13	4·62	36″·9	1°·3
February	22	7·55	44·1	1·8
March	17	6·12	40·1	1·5

When these numbers are compared with those obtained for the last three months of 1890, a marked increase is apparent. In addition to this the results obtained for spots, faculæ, and prominences indicate that a secondary maximum of solar activity occurred during the month of February.

The Constant of Aberration.—A short time ago MM. Lœwy and Puiseux described the principle of their new method of studying annual aberration and the general conclusions deduced from the observations made last year (see Nature, vol. xliii. p. 498). In *Comptes rendus*, No. 20 (May 19) they give a detailed account of the *modus operandi*, and the numerical values obtained by the observation of two groups of four stars. The mean of all the observations gives for the constant of aberration the value $20''\cdot447 \pm 0''\cdot024$.

ANIMAL LIFE ON A CORAL REEF.[1]

In nearly all the shallow waters of the tropical seas there is an abundant fauna, but nowhere is there such a crowd of marine animals of all kinds as there is in the region that extends from the growing edge of the coral reef to a depth of some 10 or 15 fathoms beyond it. This may be due to the fact that in this region there is plenty of light and heat, no great or sudden changes of temperature, or of the chemical composition of the water, and there is an abundant food supply brought by tidal currents from the surface of the ocean. Here it is, then, that we find the richest fauna. Here it is that the struggle for existence is most severe, and here it is that the animals are protected and concealed by the most pronounced marks and colours, and provided by Nature with various forms of armour, stings and spines to defend them in the battles with their enemies.

One of the most interesting results of this severe struggle for existence, or perhaps it would be more correct to say of the large number of species competing for existence, is the important faunistic difference that may be observed between one reef and another—nay, indeed, between one part of a reef and another part of the same reef.

Darwin long ago pointed out that in the struggle for existence a very slight advantage gained by any one of the competing species may entirely alter the whole aspect of the field ; and it follows that a very slight though constant difference in the physical conditions, such, for example, in the case of coral reefs, as rapidity of tidal currents, amount of surf or character of the shore rocks, may completely change the characteristics of the fauna. There are, it is true, some genera and species that are apparently found on all the reefs, such as Tubipora and Madrepora, but every reef has its own peculiar characters, and a naturalist never feels when he is examining one that he has seen something exactly like it on any previous occasion.

The majority of the corals that are found on the reefs of North Celebes belong to two great orders—the Zoantharia and Alcyonaria. The prevailing colour of the living Zoantharia is dull greeny-brown. The tentacles and the oral disks, and in some cases the growing or younger branches as a whole, may be very brightly coloured. White, pink, emerald green, violet, and blue, are colours frequently met with in different parts of the Zoantharian colony. The colours of the Alcyonarians may be due to the bright red, yellow, or purple spicules, or to the rich brown or green colour of the soft parts. There is very considerable variation in the colour of the soft parts of the Alcyonaria. The tentacles of the polyps of Tubipora, for example, may be any shade between bright green and pinkish-brown. A species of Sarcophytum, again, common on the shores of Celebes, showed green and greenish-yellow and yellow examples within the same half-mile of reef. All of these coral colours, with the exception of the colour of the spicules mentioned above, are soluble in spirit, the soft parts becoming, after prolonged immersion in this fluid, pale brown. The alcohol extracts of a considerable number of corals have now been submitted to spectrum analysis, and the bands they exhibit show close affinities with vegetable chlorophyll.

There is no experimental evidence at present that proves that the colours of the corals, nor, indeed, of the sponges, are either protective or warning in function. It seems much more probable that these brilliant colours represent different stages in the building up or breaking down of some complex chemical substance that is always present in marine zoophytes, and performs some important physiological function.

Besides the numerous sponges, corals, holothurians, mollusks, &c., that are attached to the bottom or creep but slowly from place to place, the numerous species of swimming animals that are capable of active movements in pursuit of prey, or escaping from their enemies, must be considered as part of the fauna of the coral reef. These include fishes, cephalopods, and crustacea, and those of them that seem to live habitually among the corals of the reef are characterized by the possession of very curious spots or stripes and very brilliant colours.

Soon after my arrival in Talisse a large lobster was brought to me marked by broad transverse bands of blue and white ; a large Squilla is not uncommon marked with similar bands of white and deep purple, and the little prawn *Stenopus hispidus*, that I found in a tidal pool close to a reef, has bands of red and white. The cephalopods have also peculiar markings. One specimen that I found, *Octopus lunulatus*, had large blue spots over its body and arms. The fishes, again, are marked with spots and stripes of various kinds and many brilliant colours.

Without going too deeply into the argument, we are justified in saying that these animals are so marked and coloured because they live among the brilliant surroundings of the coral reef ; or, to put it in another way, animals similarly organized and of similar habits would be at a disadvantage on the coral reefs if they were not so marked and coloured. The other fishes of the tropics do not possess these curious and beautiful characters ; the sharks, bonitos, flying fishes, herrings, and others that do not live habitually on the coral reefs are not unlike in general colour and ornamentation the fish of temperate seas. Again, the crustacea and fish of the tropical rivers and lakes are not as a rule characterized by any peculiar colouring or marking. These peculiarities, then, are not directly due to the high temperature and bright light of the tropics, but they are due to the character of the surroundings.

Most of the colours must be considered to be concealment

[1] Abstract of Lecture by Dr. S. J. Hickson, delivered at the London Institution, January 22, 1891.

colours. *Stenopus hispidus*, though so very conspicuous when taken out of the water, was extremely difficult to see in the pool where I found it. I should, in all probability, have failed to notice it, had I not quite unintentionally and blindly touched it with my stick. Like all animals protected by concealment colours, it remained perfectly motionless when alarmed. When looking down on to the growing edge of a reef from a boat on a calm day, it is very difficult at first to see anything but the corals and sponges. After a time, when the eyes become more accustomed to the light, the fish may be distinguished. Those that are coloured blue are much less readily seen than the gold, yellow, and red varieties; but an examination of the fish that I caught myself, and were caught for me by the natives, showed that the fish in which blue is the prevailing colour are much more frequent in the very shallow water, while those that were caught in water from 15 to 20 fathoms were more frequently red or yellow. The blue colour seems to be a protection for the fish from air-breathing enemies—the eagles, ospreys, and hawks—and as these enemies can only approach them from above, the colours are frequently confined to the dorsal sides. The red and yellow colours of the fish seem to be a protection from animals, such as the sharks, perch, and other carnivorous fish, that approach them from the deeper waters beyond the reefs. Thus red and yellow fishes rarely have these colours confined to the upper sides, and many of the blue fishes are coloured red or yellow ventrally.

It is difficult to frame any general rule to account for the curious distribution of the colours of these animals in spots and stripes. Speaking in very general terms, for there are many exceptions, the fish that browse on the corals, possessing small mouths and chisel-shaped teeth (such as the Chætodons, Trigger fish, and Surgeons), are striped; those that feed on other fish, and have large mouths armed with carnivorous teeth, such as the Serranidæ, are spotted.

The only example of what appears to be a warning colour that I have noticed occurs in connection with the spines on the tails of certain Surgeons and Trigger fish. *Acanthurus achillis*, for example, has a uniform purple colour, but there is a bright red patch surrounding the formidable tail spines that give these fish the name of Surgeons. Similar warning colours are very pronounced also in *Naseus unicornis* and *Naseus lituratus*, and in some of the Balistidæ.

WASHINGTON MAGNETIC OBSERVATIONS, 1886.[1]

THIS volume contains the results that have been obtained from the magnetic observations taken at the Naval Observatory during the years 1888 and 1889. The instruments with which they were made were, in the year 1887, placed in their respective buildings that had been erected for that purpose by the Bureau of Navigation. In the construction of these buildings the greatest care was taken to insure the complete elimination of local disturbances. No iron or any magnetic material was used at all, and the fastenings, &c., were entirely of copper, brass, and wood; even the stoves, in which only wood was burnt, were of soap-stone, with copper pipes.

The instruments that were employed consisted of a declinometer, theodolite, portable magnetometer, dip-circle, a set of self-recording magnetographs, a seismoscope, and seismograph; each of them, with the exception of the last two mentioned, being set on piers based on concrete, and in no way connected with the floors of the buildings. To complete the equipment, a compass-testing stand is placed on a pier north of the theodolite, and is capable of motion in an east and west direction. By means of an arm carrying two prisms that have adjusting screws, the opposite marks on the compass card can be placed in the field of view of the theodolite when the latter is directed on the prisms. All the observations, which are represented in tabular form, denote the results that have been obtained after applying all necessary corrections. The tables include, among others, the mean hourly values of the horizontal and vertical force for each month of 1889, and of the declination for each month of 1888 and 1889, the last of which are taken from the monthly curves; declination ordinates for each hour, in minutes of arc taken from daily declination traces; hourly values of horizontal and vertical force in absolute measure with all corrections; observations of horizontal intensity and dip, with a summary of disturbances in declination which differed two minutes or more from the mean monthly curve.

No less important is the series of the fourteen large plates at the end of the volume. The first shows the way that the daily photographic traces of declination, horizontal and vertical force are recorded; while the second illustrates the mean diurnal variation of the magnetic elements for the year 1889. In this latter plate the curve that gives the integration of these elements—that is, that gives the mean diurnal total force—brings out the fact that in every twenty-four hours there are two maxima and two minima, these latter two occurring between midnight and noon (75th meridian mean time).

Plates iii. to vi. inclusive show the traces of the monthly composite curves of declination for the two years.

In Plates vii. to xiv. most interesting comparison is made of the disturbed days of declination taken from observations at Washington, Los Angeles (California), Toronto (Canada), and Pawlowsk (Russia): the curves are all computed for the same time (*i.e.* for the 75th meridian west of Greenwich), and reduced to the same length of base line. Although on the whole the curves show a more or less equal variation, yet there are some cases in which a decided local variation has taken place. For instance, on January 20, between the hours of noon and four o'clock (75th meridian time), the magnetic declination at Washington, Los Angeles, and Toronto, shows only slight variations, while at Pawlowsk the disturbance is in comparison quite large. Another very interesting case happens on March 17, when the curves traced at Washington and Toronto are quite similar to each other, but different from those traced at the other two places: the curve showing the magnetic disturbances in declination at Pawlowsk being very similar to that indicating the horizontal force at Washington.

[1] Appendix I.—"Magnetic Observations." By Ensign J. A. Hoogewerff, U.S. Navy. (Washington: Government Printing Office, 1890.)

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The subject of the Rede Lecture, to be given by Sir Alfred Lyall on June 17, is "Natural Religion in India."

The General Board of Studies have again brought forward proposals for the increase of the stipends paid to University Lecturers and Demonstrators in Natural Science, which had to be postponed last year owing to want of funds.

Mr. A. Hutchinson, Demonstrator of Chemistry in Caius College, has been recognized as a Teacher of Chemistry with reference to the regulations for medical degrees.

A Syndicate is proposed by the Council of the Senate for the purpose of considering whether any alternative for Greek should be permitted in the Previous Examination. This is sure to rouse much agitation, but it may be hoped that the long-vexed question will at length be settled in a liberal sense.

Another Syndicate is to consider the office of Superintendent of the Museums of Zoology and Comparative Anatomy, about to be vacated by Mr. J. W. Clark, Registrary. Some rearrangement of the duties, &c., is considered desirable.

SCIENTIFIC SERIALS.

American Journal of Science, May.—On the relationship of the Pleistocene to the pre-Pleistocene formations of the Mississippi basin, south of the limit of glaciation, by T. C. Chamberlain and R. D. Salisbury.—On certain measures of the intensity of solar radiation, by William Ferrel. The author shows that many measures of the intensity of solar radiation are of uncertain value. He specially discusses M. Crova's curves of the relative intensities of solar radiation, obtained at Montpellier with a modified form of the thermopile, called the registering actinometer.—Geological age of the Saganaga syenite, by Horace V. Winchell.—On a self-feeding Sprengel pump, by H. L. Wells.—Contributions to mineralogy, No. 50, by F. A. Genth; with crystallographic notes by S. L. Penfield and L. V. Pirsson. The composition and habits of the following minerals are given: three new varieties of axinite, eudialyte, and monticellite, and titanite from Magnet Cove, Arkansas.—

Contributions to mineralogy, No. 51, by F. A. Genth. A new species, which has been named aguilarite, is described. It appears to be a cupriferous stephanite with an admixture of metallic silver.—Columbite of the Black Hills, South Dakota, by W. P. Blake.—The raised reefs of Fernando de Noronha, by Henry N. Ridley.—The cause of active compressive stress in rocks and recent rock flexures, by T. Mellard Reade.—A new phosphate from the Black Hills of South Dakota, by W. P. Headden.—Note on certain peculiarities in the behaviour of a galvanometer when used with the thermopile, by Ernest Merritt.—Supplementary notice on the polycrase of North and South Carolina, by W. E. Hidden and J. B. Mackintosh.

The *American Meteorological Journal* for March contains:—An article by S. M. Ballou, on Prof. Russell's theory of cold waves, published in the Report of the Chief Signal Officer for 1889. This article is a reprint of a paper read at the meeting of the New England Meteorological Society on January 20 last. According to Prof. Russell's theory, the cause of the cold area from which the cold wave is drawn is held to be a preliminary strong upward diminution of temperature in the air, a subsequent overturning, bringing the cold air to the surface and producing uniform temperature upwards, and a further cooling above, producing high pressure. The author points out that each of these assumptions would probably be questioned, and he considers each of them in detail, quoting from the works of various authorities upon the subject.—Temperature in high and low areas. This is a translation of the substance of a reply by Dr. Hann, in the *Meteorologische Zeitschrift* of September 1890, to the criticisms of Prof. Hazen. These papers have already been noticed at length in Nature.

SOCIETIES AND ACADEMIES.

London.

Royal Society, April 30.—"The Passive State of Iron and Steel, Part III." By Thos. Andrews, F.R.S., M.Inst.C.E.

Series V., Set 1. *Relative Passivity of Wrought-iron and various Steel Bars, and the Influence of Chemical Composition and Physical Structure on their Passive State in Cold Nitric Acid.*—The passive state of iron or steel may have hitherto been regarded by many as a sort of fixed property pertaining to iron and steel alike, when immersed in cold strong nitric acid. The following experiments were made to investigate if the passivity was of a universally static character, or whether it varied with the chemical composition and general physical structure of the metal, and, if so, to what extent.

The experiments of Series V., Set 1, were made on bars of the various steels selected from the author's standard samples. The bars were cold drawn through a wortle, and were therefore different in physical structure to the rolled plates used in the second series of the experiments. An idea of their general properties will be obtained on reference to Part II., Tables IV. and V. A polished bar, 8¼ inches long, 0·310 inch diameter, of the steel to be tested was placed in the wooden stand W, along with a polished wrought-iron bar of equal size, and the pair were then immersed in 1¼ fluid ounce of nitric acid, 1·42 sp. gr., contained in the U-tube, the bars being in circuit with the galvanometer. The immersion was continued for the periods stated, and with the electro-chemical results given on Table VI.

The wrought-iron bars used in each experiment were cut from one longer polished rod, so as to afford a fair comparison of the relative passivity of the various steels, compared with the wrought-iron and also with each other. The results are the average of numerous experiments in each case.

The experiments of Series V., Set 1, on the relative passivity of wrought-iron, soft cast-steel, hard cast-steel, soft Bessemer steel, and tungsten steel, showed that wrought-iron was electro-positive to the steels with a considerable E.M.F., the wrought-iron being thus shown to be less passive than the steels.

Series V., Set 2. *Relative Passivity of Wrought-iron and various Steel Plates in Cold Nitric Acid*, sp. gr. 1·42.—In the following series of observations, the metals experimented upon consisted of plates of rolled wrought-iron, rolled steels made by the Bessemer, Siemens-Martin, or crucible cast steel processes, such as soft cast-steel, hard cast-steel, soft Bessemer steel, hard Bessemer steel, soft Siemens steel, hard Siemens steel, and they are of the chemical composition given on Table VII. The terms "soft" and "hard" relate only to difference of percentage of combined carbon, and not to their having undergone annealing or hardening processes. Each plate was 3 inches square, by ⅛ inch thick = total area of exposure 19·5 square inches including edges, brightly polished all over, and had a long thin strip left on the top side, for convenience of attaching to the galvanometer connections. The whole of the wrought-iron plates, used as elements with the various steel plates, were cut from one larger wrought-iron plate, and were thus practically of uniform composition, thus ensuring an accurate comparison of the relative passivity of the wrought-iron compared with the different types of steels, and at the same time indicating relatively the influence of varied composition and structure on the passivity of the different classes of steels under observation. In each experiment, a polished wrought-iron plate and a polished steel plate were firmly placed in two small holes drilled through a thick plate-glass cover; the cover holding the two plates was then carefully placed closely over a porcelain vessel containing 15 fluid ounces of nitric acid, sp. gr. 1·42, the plates being fully immersed in the acid, and the protruding shanks of the bars connected in circuit with the galvanometer. The electro-chemical effects observed were then taken in the usual manner, and the results are given in detail on Table VIII., and indicated that wrought-iron was less passive than the steels, and further demonstrated that steels of a higher percentage of combined carbon are more passive than those of a lower percentage of combined carbon.

General Remarks.—It has been necessary to give in modified detail the effects observed during the periods of experimentation recorded on the Tables, Parts I., II., and III., so as to convey an accurate intimation of the method and nature of the research; and a brief *résumé* of some of the principal results and conclusions arrived at by the author up to the present time may now be given.

(1) The experimental observations of Part I., Series I., indicate that the influence of magnetization on the passive state of steel rods in cold nitric acid, sp. gr. 1·42, is not very great, but it was detectable with the delicate galvanometer and by the sensitive electro-chemical method pursued by the author in the investigation.

The effect of magnetization is more marked in warm nitric acid and when the iron is in a powdered state, as shown in the independent and separate experiments of Messrs. Nichols and Franklin on passive powdered iron in warm nitric acid, previously alluded to in Part I., by whom it was shown that the temperature of transition from the passive to the active state was very materially lowered by powerful magnetism; their experiments also indicate that the passive state of powdered iron cannot be fully overcome, even under strong magnetic influence, until a temperature of about 51° C. is reached.

(2) The author's experiments of Part I., Series II., at higher temperatures, confirm those of Part I., Series I., and further tend to demonstrate the influence of magnetization in somewhat lessening the passivity of steel, showing that even previous to the critical temperature point of transition from the passive to the active state, magnetized steel bars were rather less passive in warm nitric acid than unmagnetized ones.

(3) The results in Part II., Series III., show that the passivity of both unmagnetized wrought-iron and unmagnetized steel in nitric acid, sp. gr. 1·42, is considerably and proportionately reduced as the temperature of the acid increases, until the temperature point of transition from the passive to the active state is reached at a temperature of about 195° F., and it was also found that the wrought-iron was less passive in the warm nitric acid than cast-steel. (See also remarks at foot of Diagram I. in Part II.)

(4) The results of the observations of Part II., Series IV., indicate that Scheurer-Kestner was, to some extent, in error in regarding the passivity of iron as not dependent on the greater or less degree of saturation of the acid. The author's experiments herein recorded have shown that the passivity of the metals employed, viz. wrought-iron, soft cast-steel, hard cast-steel, soft Bessemer steel, and tungsten steel, was very materially increased with the concentration of the nitric acid; and it was also observed that wrought-iron was much less passive in the nitric acid of less concentration than most of the steels, the soft Bessemer steel being found about equal in passivity to the wrought-iron under the conditions of experimentation. A re-

ference to Table III. shows that a considerable amount of E.M.F. was developed between the various metals in every instance, which is a circumstance of much interest in connection with the passive state of iron and steel.

(5) The results obtained in Part III., Series V. and VI., on the relative passivity of wrought-iron and the various steels—soft cast-steel, hard cast-steel, soft Bessemer steel, hard Bessemer steel, soft Siemens steel, and hard Siemens steel—are of an important character, showing, by the delicate electro-chemical method employed, the sensitive influence of difference in chemical composition and physical structure, &c., on the passive state of the metals. Generally throughout this series of experiments it will be observed that the wrought-iron was electro-positive to the steels with a considerable E.M.F., amounting, in some cases, to as high as one-tenth to one-seventh of a volt, the wrought-iron being thus shown to be less passive than the steels.

A reference to the experiments on the wrought-iron and various steel plates, on Table VIII., shows that the E.M.F. between the passive wrought-iron and the various soft steels, which contained less percentage of combined carbon, in circuit in cold nitric acid, sp. gr. 1·42, was very considerably less than the E.M.F. under similar conditions between the wrought-iron plates and the different hard steels having a higher percentage of combined carbon. The latter results, therefore, demonstrate the interesting circumstance that steels of a higher percentage of combined carbon are more passive than those of a lower percentage of combined carbon. It will be observed that the wrought-iron was also electro-positive to most of the steels, whether of a higher or lower percentage of combined carbon, which shows that wrought-iron may be regarded as generally less passive than steels.

May 14.—"Researches on the Structure, Organization, and Classification of the Fossil Reptilia. VII. Further Observations on *Pareiasaurus*." By H. G. Seeley, F.R.S., Professor of Geography in King's College, London.

All the affinities hitherto attributed to *Pareiasaurus* with Labyrinthodonts, Anomodonts, *Procolophon*, and Mammals are shown more strongly in the several parts of the skeleton, by the new evidence. The shoulder-girdle is more Labyrinthodont than was previously supposed, the skull is more Reptilian, and the pelvis and limbs are more Mammalian, though with some resemblance to Dinosaurs.

From furthur evidence of the structure of the skeleton in *Procolophon*, the author regards that type as a member of the Pareiasauria, rather than as forming a distinct sub-order. It also has four sacral vertebræ.

The divisions of the Anomodontia are grouped as—

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              Theriodontia.
             /      |      \
   Placodontia.     |     Dicynodontia.
      |      \      |      /      |
      |      Endothiodontia.      |
      |      /             \      |
   Pareiasauria.           Mesosauria.
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Physical Society, May 9.—The Society varied its ordinary procedure by paying a visit to the ancient seat of learning situated on the banks of the Cam. Assembling at Liverpool Street Station, members and visitors to the number of about one hundred were conveyed in saloon carriages by the 11 o'clock express direct to their destination, the whole journey being accomplished in about seventy-five minutes. Amongst those present were Dr. E. Atkinson, Prof. Ayrton and Mrs. Ayrton, Mr. Walter Baily, Mr. Shelford Bidwell and Mrs. Bidwell, Mr. D. J. Blaikley, Mr. T. H. Blakesley and Mrs. Blakesley, Mr. J. T. Bottomley, Mr. C. V. Boys, Prof. Carey Foster, Mr. Conrad W. Cooke, Prof. Fitzgerald, Dr. E. Frankland and Mrs. Frankland, Dr. W. R. Hodgkinson, Prof. O. J. Lodge, Prof. Meldola, Prof. Perry and Mrs. Perry, Prof. Rücker, Dr. Sumpner, Prof. S. P. Thompson and Mrs. Thompson, Mr. A. P. Trotter and Mrs. Trotter, and Mr. G. M. Whipple. On arriving at the historic town the party became the guests of the Cambridge members, and proceeded to Emmanuel College, where they were received by Mr. W. N. Shaw. Various groups visited the cloisters, chapel, and gardens, and at one o'clock lunch was provided in the College Hall. At 2.30, a meeting of the Society was held in the Lecture Room of the Cavendish Laboratory. The papers read were all by authors resident in Cambridge, and the abstracts given below will sufficiently indicate the variety of the subjects brought before the Society. After the meeting the visitors inspected the Cavendish Laboratory. Amongst the many interesting instruments and apparatus to be seen, specially noticeable were Prof. J. J. Thomson's 50-feet vacuum tube, glowing from end to end with a luminous discharge; Mr. Shaw's pneumatic bridge, by which the pneumatic resistance or conductivity of various shaped orifices and channels can be compared; and the new air condensers to be used by Mr. Glazebrook as standards. The Cambridge Scientific Instrument Company had an interesting exhibit, including a dividing engine, Boys's radio-micrometer, electrically driven tuning-forks, and various recording instruments, amongst which was Galton's apparatus for registering the growth of plants. Other things which attracted attention were Glazebrook's spectrophotometer; Lord Rayleigh's coils and apparatus used in his determination of the ohm; a collection of models, medals, and instruments, formerly belonging to Prof. Maxwell; the resistance standards of the British Association, together with the historic rotating coils and electrodynamometer used in the determination of the B.A. unit. Tea was served in the Combination Room of Trinity College, and a majority of the visitors returned to town by the 8 o'clock express, greatly pleased with the day's outing. Others, however, prolonged their visit until Monday, and had opportunities of discussing important physical problems with the Cambridge members. The meeting was in every sense a great success, and will long be remembered as a red-letter day in the history of the Society.—At the science meeting, held in the Cavendish Laboratory, Prof. Ayrton, F.R.S., President, in the chair, the following communications were made:—Some experiments on the electric discharge in vacuum tubes, by Prof. J. J. Thomson, F.R.S. The phenomena of vacuum discharges were, he said, greatly simplified when their path was wholly gaseous, the complication of the dark space surrounding the negative electrode and the stratifications so commonly observed in ordinary vacuum tubes being absent. To produce discharges in tubes devoid of electrodes was, however, not easy to accomplish, for the only available means of producing an electromotive force in the discharge circuit was by electro-magnetic induction. Ordinary methods of producing variable induction were valueless, and recourse was had to the oscillatory discharge of a Leyden jar, which combines the two essentials of a current whose maximum value is enormous, and whose rapidity of alternation is immensely great. The discharge circuits, which may take the shape of bulbs or of tubes bent in the form of coils, were placed in close proximity to glass tubes filled with mercury, which formed the path of the oscillatory discharge. The parts thus corresponded to the windings of an induction coil, the vacuum tubes being the secondary and the tubes filled with mercury the primary. In such an apparatus the Leyden jar need not be large, and neither primary or secondary need have many turns, for this would increase the self-induction of the former and lengthen the discharge path in the latter. Increasing the self-induction of the primary reduces the E.M.F. induced in the secondary, whilst lengthening the secondary does not increase the E.M.F. per unit length. Two or three turns in each were found to be quite sufficient, and on discharging the Leyden jar between two highly polished knobs in the primary circuit a plain uniform band of light was seen to pass round the secondary. An exhausted bulb containing traces of oxygen was placed within a primary spiral of three turns, and on passing the jar discharge a circle of light was seen within the bulb in close proximity to the primary circuit, accompanied by a purplish glow which lasted for a second or more. On heating the bulb, the duration of the glow was greatly diminished, and it could be instantly extinguished by the presence of an electro-magnet. Another exhausted bulb surrounded by a primary spiral was contained in a bell jar, and when the pressure of air in the jar was about that of the atmosphere, the secondary discharge occurred in the bulb, as is ordinarily the case. On exhausting the jar, however, the luminous discharge grew fainter, and a point was reached at which no secondary discharge was visible. Further exhaustion of the jar caused the secondary discharge to appear outside the bulb. The fact of obtaining no luminous discharge either in the bulb or jar the author could only explain on two suppositions, viz. that under the conditions then existing the specific inductive capacity of the gas was very great, or that a discharge could pass without being luminous. The author had also observed that the conductivity of a vacuum tube without electrodes increased as the pressure diminished, until a certain point was reached, and afterwards diminished again, thus showing that the high resistance of a nearly perfect vacuum is in no way due to the presence of the electrodes. One peculiarity of the discharges was their local nature, the rings of light being much more sharply defined than was to be expected. They were also found to be most easily produced when the chain of molecules in the discharge were all of the same kind. For example, a discharge could be easily sent through a tube many feet long, but the introduction of a small pellet of mercury in the tube stopped the discharge, although the conductivity of the mercury was much greater than that of the vacuum. In some cases he had noticed that a very fine wire placed within a tube on the side remote from the primary circuit would present a luminous discharge in that tube.—Some experiments on the velocities of the ions, by Mr. W. C. D. Whetham. In studying electrolysis the question as to whether there is any transference of solvent when a porous wall is absent presented itself to the author. The ordinary methods of testing for transference, such as by increase of pressure, or by overflow, not being available, when there is no diaphragm, the author used different coloured solutions of the same salt, such as cobalt chloride in water and in alcohol, the former of which is red and the latter blue. By putting the solutions into a kind of U-shaped tube any change in the position of the line of junction of the two liquids could be measured. Two aqueous solutions in which the anion was the same were also tried, one combination being cupric chloride and common salt, and in this case the line of demarcation traversed about 7 inches in three hours. The results hitherto obtained by this method agreed fairly with those found by Kohlrausch.—On the resistance of some mercury standards, by Mr. R. T. Glazebrook, F.R.S. In 1885, M. Benoit, of Paris, supplied the author with three mercury standards, nominally representing the Paris Congress ohm, now commonly known as the legal ohm. Tests of these standards were described in a paper read before the Physical Society in 1885 by the present author. Recently he had occasion to compare two of the standards with the British Association coils. The mean of many concordant results gave the resistance of one of the mercury standards (No. 37) as 1·01106 B.A.U., whilst that of the other (No. 39) was 1·01032 B.A.U. Expressing them in legal ohms the present resistances are (No. 37) 0·99986 and (No. 39) 0·99913, whilst in 1885 the values obtained were (No. 37) 0·99990 and (No. 39) 0·99917. This shows that within the limits of experimental error the ratios of the mercury standards to the B.A. coils have remained practically unchanged during six years. The numbers given above are based on Lord Rayleigh's determination of the specific resistance of mercury, which differs appreciably from that found by Mascart and other observers. Taking the mean of the later concordant determinations, the values of the mercury standards expressed in legal ohms become (No. 37) 1·00033 and (No. 39) 0·99959. The values given by the maker were 1·00045 and 0·99954 respectively, showing a very close agreement. The author also found that refilling No. 37 from the same sample of mercury produced no appreciable change in its resistance, whilst No. 39 was somewhat affected by a similar operation. Experiments on the co-efficient of increase of resistance of mercury with temperature gave the value 0·000872 as the mean coefficient between 0° and 10° C., a number rather less than that obtained by Kohlrausch.—On an apparatus for measuring the compressibility of liquids, by Mr. S. Skinner. The apparatus consisted of a large spherical flask, with a long narrow neck containing the liquid to be experimented upon, the lower part of which was in communication through a stopcock and flexible tube with an adjustable reservoir. By raising or lowering the latter the flask could be easily filled or emptied or the quantity of liquid adjusted. The flask was inclosed in a bell jar, whose interior was in communication with a pump and barometer gauge. So sensitive was the arrangement that the compression of water produced by blowing into the jar caused the liquid to descend about 1 centimetre in the neck of the flask. This movement corresponded with a change of volume of about half a millionth. The coefficient of compressibility had been tested at different temperatures, and the results were not very different from those obtained by Tait and others. The influence of salts in solution in changing the compressibility had also been tested, and a great difference in this respect found between electrolytes and non-electrolytes.—Some measurements with the pneumatic bridge, by Mr. W. N. Shaw. The action of the apparatus is analogous in many respects to the Wheatstone's bridge, and its object is to compare the pneumatic resistances or conductivities of various orifices, channels, tubes, &c. The proportional arms are represented by two circular holes in thin plates of mica, the third arm by an aperture provided with a sliding shutter adjustable by a screw, and the fourth might consist of any aperture or tube whose conductivity was to be determined. The several apertures are pneumatically connected by large wooden boxes. The battery takes the form of a Bunsen burner with a long chimney, whilst the galvanometer is represented by a glass tube connecting opposite chambers, and containing a vane which sets itself at right angles to the tube when no air current is passing. The apparatus is remarkably sensitive to movements of the shutter, and on starting or stopping the draught after balance had been obtained, effects analogous to those produced by self-induction are observed. By its use it has been found that bevelling off one side of a hole in a thin plate increases the pneumatic conductivity of the aperture very considerably, particularly when the bevel is on the egress side. Another interesting result is that for square-ended tubes of given size the conductivity first increases as the length is made greater, and afterwards diminishes with further increase of length. Putting a flange on the outlet end reduces the anomalous effect, whilst a bevelled mouthpiece similarly placed causes it to disappear. In the discussion on Prof. Thomson's paper, Prof. Fitzgerald said the beautiful experiments were likely to lead to very important results. He did not quite understand how placing a fine wire in a vacuum tube could prevent the luminous discharge, for if the wire was on the side remote from the primary, and if there was any great increase in specific inductive capacity, he would have expected the air to screen the wire. Prof. Lodge asked for further information as to the action of the magnet in preventing the after-glow, and in some cases precipitating a luminous discharge. The experiment with the exhausted bulb within the bell jar was also difficult to understand, and he did not see why one of Prof. Thomson's two suppositions must necessarily be true. The President inquired whether Prof. Thomson had tried Mr. Crookes's experiment, in which the electric pressure necessary to produce a discharge was greatly lessened by putting a phosphorescent material in the tube. Prof. Thomson, in reply, said he had not tried the experiment, but the phosphorescence he had observed was of quite a different character from that produced in Mr. Crookes's tubes. To Prof. Fitzgerald he said the action of the wire was probably a question of time, and thought the whole field was in some way thrown on the wire and thus discharged. In reply to Prof. Lodge, he had not ascertained the true nature of the effect of a magnet on the glow, but he believed the glow to be due to a combination which might be prevented or facilitated by the action of the magnet causing the density to be different in different parts of the bulb. M. Guillaume, in discussing Mr. Skinner's paper, described the methods used by Sabine, Jamin, and others, in determining the compressibility of liquids, and pointed out their defects. The chief difficulty in such experiments was in finding the compressibility of the reservoir. Numbers expressing the compressibility of mercury obtained by different observers were given, the best values varying between 0·0000039 and 0·0000040.—On the motion of Prof. Ayrton, seconded by Prof. Rücker, a hearty vote of thanks was accorded to the authors for their valuable and interesting communications, and for the kind manner in which the Society had been received and entertained by the Cambridge members. Prof. Thomson and Mr. Glazebrook acknowledged the vote.

Geological Society, May 6.—Dr. A. Geikie, F.R.S., President, in the chair.—The following communications were read:—On a Rhætic section at Pylle Hill or Totter Down Bristol, by E. Wilson. In a deep railway-cutting at Pylle Hill, the Rhætic beds, having a thickness of not more than seventeen feet, are exposed between the Tea-Green Marls and the Lower Lias. There is no doubt as to the division between the Rhætic and Keuper beds in this section, but the line of demarcation between the Rhætic and the Lias has always been a matter of uncertainty in the West of England. In connection with this subject the term "White Lias," as applied to beds some of which are Rhætic and others Liassic, is held to be unsatisfactory. The author takes a limestone which is the equivalent of the Cotham Marble as the highest Rhætic bed in the section described. He divides the Rhætic beds of the cutting into an Upper Rhætic series and *Avicula contorta* Shales. The intimate connection betwixt the Tea-Green Marls and the Red Marls of the Upper Keuper is well displayed, whilst there is a sharp line of demarcation between the former and the *Avicula contorta* Shales. Most of the characteristic fossils of the British Rhætic are met with at Pylle Hill, together with a few forms which are new to England, and some of these possibly to science. A detailed section of the subdivisions of the Rhætic and adjacent beds, and a list of Rhætic fossils found in the section are given by the author. After the reading of the paper some remarks were made by Mr. Etheridge, Mr. H. B. Woodward, the Rev. H. Winwood, and Prof. T. Rupert Jones.—A microscopic study of the Inferior Oolite of the Cotteswold Hills, including the residues insoluble in hydrochloric acid, by Edward Wethered. The author gives the following main divisions of the Inferior Oolite of the Cotteswold Hills in descending order :—

Ragstones.
Upper Freestones.
Oolitic Marl.
Lower Freestones.
Pea Grit.
Transition Beds resting on Upper Lias.

The strata are described, and the results of microscopic examination of the different beds given. These latter confirm the author's views as to the important part which *Girvanella* have taken in the formation of oolitic granules ; whilst an examination of the borings referred to by Prof. Judd in the discussion of Mr. Strahan's paper "On a Phosphatic Chalk," convinces the author that these have no connection with the genus *Girvanella*. In the second part of the paper the insoluble residues left after treating the various deposits with acid are considered. They contain chiefly detrital quartz, felspars, zircons, tourmaline, chips of garnet, and occasionally rutile. In the argillaceous beds silicate of aluminia was found to occur plentifully. The detrital material is considered to be due to denudation of crystalline felspathic rocks, and not of stratified ones. This view seems to be supported by the quantity of felspar and its good state of preservation. The paper concludes with a consideration of the quantity of residue and the size of the quartz-grains in the different deposits, which are summarized in the following table :—

	Percentage of residue.	Size of quartz-grains, in millim.
Ragstones	2·8 ...	·17
Upper Freestones ...	1·1 ...	·12
Oolitic Marl	3·2 ...	·09
Lower Freestones ...	1·8 ...	·13
Pea Grit Series	5·0 ...	·14
Transition Beds	38·3 ...	·13

This shows a great falling off in the percentage of residue above the Transition Beds. That of the Freestones is remarkably low, and it would appear that these rocks were formed under conditions which allowed of very little sediment being deposited. The paper gave rise to a discussion, in which Prof. Hull, Mr. Etheridge, Mr. H. B. Woodward, the Rev. H. Winwood, and the author took part.

Royal Meteorological Society, May 20.—Mr. Baldwin Latham, President, in the chair.—The following papers were read :—On the vertical circulation of the atmosphere in relation to the formation of storms, by Mr. W. H. Dines. After giving an outline of the circulation of the atmosphere, the author refers to the two theories which have been suggested to account for the formation of storms, viz. (1) the convection theory, which is that the central air rises in consequence of its greater relative warmth, this warmth being produced by the latent heat set free by condensation ; and (2) the theory that the storms are circular eddies produced by the general motion of the atmosphere as a whole, just as small water eddies are formed in a flowing stream of water. The author is of opinion that the convection theory is the more probable of the two, but more information about the temperature of the upper air is greatly needed.—On Brocken spectres in a London fog, by Mr. A. W. Clayden. During the dense fogs in February last, the author made a number of experiments with the view of raising his own spectre. This he ultimately succeeded in accomplishing by placing a steady limelight a few feet behind his head, when his shadow was projected on the fog. He then made some careful measurements of the size and distance of the spectre, and also succeeded in taking some photographs of the phenomenon.—An account of the "Leste," or hot wind of Madeira, by Dr. H. Coupland Taylor. The "Leste" is a very dry and parching wind, sometimes very hot, blowing over the island from the E.N.E. or E.S.E., and corresponds to the sirocco of Algeria, or the hot north winds from the deserts of the interior experienced in Southern Australia. During its prevalence a thin haze extends over the land, and gradually thickens out at sea until the horizon is completely hidden. It is most frequent during the months of July, August, and September, and usually lasts for about three days.—Mr. Shelford Bidwell, F.R.S., exhibited an experiment showing the effect of an electrical discharge upon the condensation of steam. The shadow of a small jet of steam cast upon a white wall is, under ordinary conditions, of feeble intensity and of a neutral tint. But if the steam is electrified, the density of the shadow is at once greatly increased, and it assumes a peculiar orange-brown hue. The electrical discharge appears to promote coalescence of the exceedingly minute particles of water contained in the jet, thus forming drops large enough to obstruct the more refrangible rays of light. It is suggested that this experiment may help to explain the intense darkness, often tempered by a lurid yellow glow, which is characteristic of thunderclouds.

Linnean Society, April 16.—Prof. Stewart, President, in the chair.—A paper by the Rev. F. R. Wilson, was read, on lichens from Victoria, in which several new species were described, specimens of which were exhibited.—A paper by Surgeon-Major A. Barclay followed, on the life-history of two species of *Puccinia*, viz. *P. coronata*, Corda, and a new species which the author proposed to name *P. Jasmini-chrysopogonis*. A feature of peculiar interest noted in the latter species was the extraordinary abundance and wide distribution of the teleutosporic stage as compared with the comparative scarcity of the æcidial stage, and this disproportion in the distribution of the two stages had been remarked by the author long before he had ascertained that they were related.—A discussion followed, in which several of the botanists present took part.

May 7.—Prof. Stewart, President, in the chair.—Prof. R. J. Anderson exhibited a panoramic arrangement for displaying drawings at biological lectures.—Mr. John Young exhibited a nest of the Bearded Titmouse (*Calamophilus biarmicus*), which had been built in his aviary. Several eggs were laid, but none of them were hatched.—The Rev. E. S. Marshall exhibited several specimens of a Cochlearia from Ben More, believed to be undescribed.—Mr. Robert Deane forwarded for exhibition a plant of the Rayless Daisy, found growing abundantly in the neighbourhood of Cardiff ; and an undetermined Sponge, dredged in about 40 fathoms, off the coast of South Wales.—Mr. D. Morris drew attention to a Jamaica drift fruit recently found on the coast of Devonshire. Although figured so long ago as 1640 by Clusius, and subsequently noticed by other observers, the plant yielding it had only lately been identified by Mr. J. H. Hart, of Trinidad, as *Sacoglottis amazonica*. Mr. Morris likewise exhibited specimens of the fruit of *Catostemma fragrans*, received for the first time, from St. Vincent, showing its true position to be amongst the *Malvaceæ*, tribe *Bombaceæ*.—Mr. Thomas Christy exhibited some Kola nuts, and made remarks on the properties attributed to their medicinal use.—A paper was then read by Mr. Malcolm Lawrie, on the anatomy of the genera *Pterygotus* and *Slimonia*, and their relationship to recent *Arachnida*. An interesting discussion followed, in which the President, Prof. Howes, Dr. H. Woodward, and others took part.

Entomological Society, May 6.—Mr. Frederick DuCane Godman, F.R.S., President, in the chair.—Dr. D. Sharp exhibited a number of eggs of *Dytiscus marginalis* laid on the sheath of a species of reed, and commented on the manner of their oviposition, which he said had been fully described by Dr. Régimbart.—The Rev. A. E. Eaton exhibited a collection of *Psychodidæ* from Somersetshire, including six species of *Psychoda*, eleven species of *Pericoma*, and one species of *Ulomyia*. Mr. McLachlan commented on the interesting nature of the exhibition.—Mr. P. Crowley exhibited a specimen of *Prothoë caledonia*, a very handsome butterfly from Perak ; and a specimen of another equally handsome species of the same genus from Tonghou, Burmah, which was said to be undescribed.—Mr. H. Goss, the Secretary, read a letter from Mr. Merrifield, pointing out that the statement made by Mr. Fenn, at the meeting of the Society on April 1 last, of his views on the effects of temperature in causing variation in Lepidoptera, was incorrect ; he (Mr. Merrifield) had never suggested what might happen to *Tæniocampa instabilis*, and had expressly stated that he had found a reduction of the temperature below 57° to produce no effect, whereas in Mr. Fenn's experiments the temperature must have been below 40°.—The Secretary also read a letter which Lord Walsingham had received from Sir Arthur Blackwood, the Secretary of the Post Office, in answer to the memorial which, on behalf of the Society, had been submitted to the Postmaster-General, asking that small parcels containing scientific specimens might be sent to places abroad at the reduced rates of postage applicable to packets of *bonâ fide* trade patterns and samples. The letter intimated that, so far as the English Post Office was concerned, scientific specimens sent by sample post to places abroad would not be stopped in future.

Mathematical Society, May 14.—Prof. Greenhill, F.R.S., President, in the chair.—The following communications were made:—Relations between the divisors of the first *n* numbers, by Dr. Glaisher, F.R.S.—Wave motion in a heterogeneous heavy liquid, by Mr. Love.—Disturbance produced by an element of a plane wave of sound or light, by Mr. Basset, F.R.S.—On functions determined from their discontinuities and a certain form of boundary condition, and on a certain Riemann's surface, by Prof. W. Burnside.—Messrs. MacMahon, Larmor, Bryan, and the President took part in the discussions on the papers.

CAMBRIDGE.

Philosophical Society, May 4.—Prof. G. H. Darwin, President, in the chair.—The following communications were made:—The most general type of electrical waves in dielectric media that is consistent with ascertained laws, by Mr. J. Larmor.—A mechanical representation of a vibrating electrical system and its radiation, by Mr. J. Larmor.—The theory of discontinuous fluid motion in two dimensions, by Mr. A. E. H. Love. The paper contains an account of a modification of Mr. Michell's method. It is shown that, in all problems where the fixed boundaries consist of parts of *straight* lines, a figure can be constructed whose conformable representation upon a half plane gives rise to the equation of transformation which contains in itself the solution of the problem. The relation by which the representation is effected can in each problem be determined by known methods. The whole subject is thus reduced to integral calculus. Several new cases of the resistance offered by obstacles to the motion of fluids are solved. These include the determination of the mean pressure on a disk with an elevated rim, and of the mean pressure on a pier or other obstruction in a canal of finite breadth.—On thin rotating isotropic disks, by Mr. C. Chree. The subject treated is that of the rotation about their axes of thin disks whose section parallel to the plane faces consists of a circle or the area between two concentric circles. The paper aims at providing a solution which is not open to the objections recently urged by Prof. Pearson in NATURE against previous solutions.

PARIS

Academy of Sciences, May 19.—M. Duchartre in the chair.—Determination of the constant of aberration; numerical values deduced from two groups of four stars, by MM. Lœwy and Puiseux.—On the transit of Mercury, by M. J. Janssen. It is remarked that a conclusive confirmation of the solar origin of the corona would be obtained if Mercury were photographed when at a short distance from the edge of the sun, and appeared in the negative projected upon a luminous background.—On the physical explanation of fluidity, by M. Boussinesq.—The heat of combustion and formation of some chlorine compounds, by MM. Berthelot and Matignon. The experiments indicate that for each equivalent of hydrogen replaced by chlorine in a series of compounds from 30 to 32 calories is disengaged. Cl_n substituted for H_n thus disengages about $30n$ calories.—On a double halo with parhelia observed on May 15, 1891, by M. A. Cornu.—On a memoir, by Herr W. von Bezold, relative to the theory of cyclones, by M. Faye.—Remarks on the employment of carbon bisulphide in the treatment of phylloxerous vines, by M. A. F. Marion and G. Gastine.—On the intermediate integrals of equations from derived partials of the second order, by M. E. Goursat.—On an elementary method of establishing differential equations of which θ functions form the integral, by M. F. Caspary.—On a class of complex numbers, by M. André Markoff.—Quantitative studies of the chemical action of light; Part iii. influence of dilution, by M. Georges Lemoine. Experiments with mixtures of oxalic acid and ferric chloride taken in equivalent proportions but with different quantities of water indicate that the chemical action of light upon them increases with the excess of water. The action of heat upon the mixtures appears to follow the same laws as that of light.—Calculation of the temperatures of fusion and ebullition of normal paraffins, by M. G. Hinrichs. A comparison is given of the observed and calculated melting and boiling points of the normal paraffins. The method of calculation is contained in *Comptes rendus*, May 4, 1891.—On the action exercised by alkaline bases on the solubility of alkaline salts, by M. Engel.—On the detection of silica in the presence of iron, by M. Leclere.—On the constitution and heat of formation of bibasic erythrates, by M. de Forcrand.—Thermal data relative to propionic acid and the propionates of potash and soda, by M. G. Massol. Facts are stated which prove that propionic acid, in combining with potash or soda, disengages as much heat as its superior and inferior homologues, acetic and butyric acids.—On the heat of dissolution and the solubility of some organic acids in methyl-, ethyl- and propyl-alcohols, by M. Timofeiew. The results indicate that there is a relation between the molecular solubility and heat of dissolution, the variation of molecular solubility carrying with it a variation, in the opposite sense, of the heat of dissolution.—Action of chlorides of bibasic acids on cyanacetic ethers, by M. P. T. Muller.—On the formation of nitrates in the earth, by M. A. Muntz.—Considerations of abysmal waters, by M. J. Thoulet.—On the genus Royena of the family Ebenaceæ, by M. Paul Parmentier.—On an inferior Basidiomycete parasite of grapes, by MM. Pierre Viala and G. Boyer.—On a particular appearance of the Cretaceous formation in the Bou-Thaleb group, Algeria, by M. E. Ficheur.—A bed of nephritis found in China, in the Nan Chan mountain-chain, by M. Martin.—Correction to a note on a recently described fossil, by M. Stanislas Meunier.—Discovery of a human skeleton contemporary with the Quaternary volcanic eruptions of Gravenoire (Puy-de-Dôme), by MM. Paul Girod and Paul Gautier.—Chemical and physiological researches on microbic secretions; transformation and elimination of organic matter by the pyocyanic bacillus, by MM. A. Arnaud and A. Charrin.

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